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MASSACHUSETTS AGRICULTURAL COLLEGE

REPORT OF THE PRESIDENT

AND OTHER OFFICERS OF ADMINISTRATION

1922

PUBLIC DOCUMENT No. 31

THE M. A. C. BULLETIN
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THE SIXTIETH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE

PART I.—THE REPORT OF THE PRESIDENT AND OTHER OFFICERS OF ADMINISTRATION FOR THE FISCAL YEAR ENDED NOV. 30, 1922

Publication of this Document
approved by the
Commission on Administration and Finance

DEPARTMENT OF EDUCATION
THE COMMONWEALTH OF MASSACHUSETTS

The Commonwealth of Massachusetts

Department of Education, Boston, February 6, 1923.

To the Honorable Senate and House of Representatives.

Gentlemen: — In accordance with the provisions of section 32 of chapter 30 of the General Laws, I transmit to you herewith, for the use of the General Court, the annual report of the Massachusetts Agricultural College for the year ending November 30, 1922.

Respectfully yours,

PAYSON SMITH,
Commissioner of Education.

Massachusetts Agricultural College,
Amherst, Nov. 29, 1922.

To the Commissioner of Education.

Sir: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to submit herewith Part I of the sixtieth annual report of the trustees, for the fiscal year ended November 30, 1922, this being the report of the president of the college and other officers of administration to the corporation.

Respectfully yours,

KENYON L. BUTTERFIELD,
President.

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Members of Advisory Board of Education

Ex officio THE COMMISSIONER OF EDUCATION, *Chairman*

Term expires		
1923.	SARAH LOUISE ARNOLD	Riverbank Court, Cambridge
1923.	MRS. ELLA LYMAN CABOT	1 Marlborough Street, Boston
1924.	WALTER V. McDUFFEE	Central High School, Springfield
1924.	ARTHUR H. LOWE	Fitchburg
1925.	A. LINCOLN FILENE	426 Washington Street, Boston
1925.	THOMAS H. SULLIVAN	Slater Building, Worcester

Massachusetts Agricultural College

KENYON L. BUTTERFIELD, *President*

Trustees

Ex officio HIS EXCELLENCY CHANNING H. COX
Ex officio PAYSON SMITH, *Commissioner of Education*
Ex officio ARTHUR W. GILBERT, *Commissioner of Agriculture*
Ex officio KENYON L. BUTTERFIELD, *President of the College*

Term expires		
1924.	HAROLD L. FROST	Arlington
1924.	FRANK GERRETT	Greenfield
1925.	CHARLES H. PRESTON	Danvers
1925.	CARLTON D. RICHARDSON	West Brookfield
1926.	DAVIS R. DEWEY	Cambridge
1926.	JOHN F. GANNON	Pittsfield
1927.	ARTHUR G. POLLARD	Lowell
1927.	GEORGE H. ELLIS	Newton
1928.	ELMER D. HOWE	Marlborough
1928.	ATHERTON CLARK	Newton
1929.	NATHANIEL I. BOWDITCH	Framingham
1929.	WILLIAM WHEELER	Concord
1930.	CHARLES A. GLEASON	North Brookfield
1930.	JAMES F. BACON	Boston

Officers of the Trustees

HIS EXCELLENCY CHANNING H. COX, *President*
CHARLES A. GLEASON of North Brookfield, *Vice-President*
RALPH J. WATTS of Amherst, *Secretary*
FRED C. KENNEY of Amherst, *Treasurer*
CHARLES A. GLEASON of North Brookfield, *Auditor*

Department of Education

Division of Elementary and Secondary Education and Normal Schools
Division of Vocational Education
Division of University Extension
Division of Education of Aliens
Division of Public Libraries
Division of the Blind
Teachers' Retirement Board
Massachusetts Nautical School
Massachusetts Agricultural College
Bradford Durfeee Textile School, Fall River
Lowell Textile School
New Bedford Textile School

REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

REVIEW OF THE YEAR.

Death of Dr. James B. Paige.

After a leave of absence of nearly one and a half years on account of illness, Dr. James B. Paige died October 5, 1922. Dr. Paige was a graduate of the Massachusetts Agricultural College in the class of 1882; subsequently he pursued the study of Veterinary Science at Montreal Veterinary College, McGill University, and in the Thierartzlichen Hochschule, Munich, Germany. He joined our teaching staff in 1890 as professor of Veterinary Science and subsequently became Head of the Department. In this capacity he directed not only the teaching but also the research of the Department, and in later years had charge of the work developed under the poultry disease elimination law. From 1909 to 1911, he served as Dean of the College in the absence of Dean George F. Mills. In the passing of Dr. Paige, the College lost an efficient teacher and a faithful servant. The following tribute was accepted by the faculty at a recent meeting:

To the memory of James Breckenridge Paige, D. V. S., member of the class of 1882 and of the faculty of the Massachusetts Agricultural College.

In the death of James Breckenridge Paige, the Massachusetts Agricultural College has lost a distinguished alumnus, teacher and friend. His connection with the college covered a period of over forty years. He served the college with distinguished success as a teacher, investigator, and administrator; he also gave valuable service to the Commonwealth as a member of the General Court.

In the discharge of these responsibilities he served his country and college with staunch integrity. He was a man of high ideals and firm principles, manifested both in his relations with his fellow teachers and students and in his devotion to the search for truth. His principles were the result of long and conscientious thought, and once determined were courageously supported in the face of every difficulty. We hold him in grateful memory as a patriotic citizen, a loyal colleague, a close personal friend.

Reorganization of the Department of Veterinary Science.

Following the retirement of Dr. Paige, the Department of Veterinary Science was reorganized as the Department of Veterinary Science and Animal Pathology with Dr. George E. Gage as Professor and Head of the Department. Dr. Gage joined our staff in 1911 and, with the exception of an absence for war service, has been in the employ of this institution since that date. He is a graduate of Clark University with the class of 1906, and pursued graduate study at Yale University from which he received the degree of M.A. in 1907 and of Ph.D. in 1909. During the war he served as captain in the Sanitary Corps of the army and spent several months in France.

Retirement of Major Frederick E. Shnyder.

As a result of the policy of the War Department to reduce materially its number of commissioned officers, Major Frederick E. Shnyder was in November placed upon the retired list. In 1920–21 Major Shnyder served as Assistant Professor of Military Science and Tactics in our institution with Col. Richard W. Walker, and upon the transfer of the latter to another post, Major Shnyder was in 1921 made Commandant. Under his direction the standard of excellence in military

drill has been constantly elevated. He was respected and liked by the students and his retirement was cause for sincere regret by students and faculty alike.

Major Herman Kobbé, who has been Assistant Professor of Military Science and Tactics since 1921, succeeds Major Shnyder as Commandant. Being thoroughly familiar with the development of the military work at this institution and having the confidence of the faculty and students, Major Kobbé will doubtless continue to maintain a high standard for the military work here.

Our good fortune in having a cavalry unit assigned to the college — one of but a half dozen in the United States — is exemplified in the increasing popularity of the military drill. We now have sixty horses from the War Department with a liberal complement of soldiers and supplies. A major and two captains are assigned for instruction service. That the students are responding to the opportunity is shown by an enrollment in the advanced course of 9 seniors and 16 juniors. The Reserve Officers Training Corps is thoroughly justifying itself so far as this College is concerned, both from the standpoint of enabling the students to get the maximum educational value from the military discipline and in the training of reserve officers for the army.

Withdrawal of Professor Lockwood.

Professor W. P. B. Lockwood, upon his request, has been relieved of his duties as Professor of Dairying and Head of the Department. This position he had held since 1909; during this period of service he rendered conspicuous service not only to the College but to the dairy interests of the state as well. Under his direction Flint Laboratory was built and equipped, and the "major" in dairying organized. Professor Lockwood is a man of unusual administrative ability and was constantly called upon to work out problems not immediately connected with his department. For example, he organized the class schedule on a permanent and satisfactory basis; this task was a difficult one due to the constantly increasing number of courses which were being placed in the curriculum as well as to the development of the major system of studies. During the war, Professor Lockwood was one of our most valuable men in organizing various types of public safety work. More recently he gave considerable attention to the work of vocational counselling of students. After the close of the war, Professor Lockwood became interested in the promotion of a more extended use of milk and other dairy products on a New England basis; and for two and one-half years before his retirement from the Head of the Department gave largely of his time to this educational promotion work. Professor Lockwood is still retained on part time pay as Professor of Extension Dairying. Professor H. F. Judkins is serving as acting Head of the Department of Dairying.

Resignations.

During the year there were fewer resignations from the professional and clerical staffs than in any of the preceding five years. There were twelve resignations from the professional staff, nineteen from the clerical and secretarial staff, and two from other salaried positions. The list of resignations does not include any department head. It appears that for the present at least the serious over-turn of staff due to inadequate salaries has been partially checked. We still fail, however, to pay our men in the more responsible positions salaries which compare favorably with those paid men holding similar positions elsewhere.

Commencement.

The usual commencement exercises were held June 23 to 27, the commencement address on June 27 being given by Bishop Francis J. McConnell of Pittsburgh, Pennsylvania. The degree of B.Sc. was conferred upon 94 men and 5 women; the degree of M.Sc. conferred upon 3 men and 1 woman; the degree of Ph.D. upon 2 men.

Burning of the Chemistry Laboratory.

-ly in the morning of September 6, the old chemistry laboratory was completely destroyed by fire. The building was valued in the college inventory at about $8,000 but its replacement value was several times that amount. In spite of considerable salvaging the loss on equipment is estimated at about $18,000. The College immediately requested the State Department of Public Safety to make an investigation as to the cause of the fire. In its judgment the fire was caused by the breaking and consequent leaking of nitric acid on to the wood work of a shelf and partition. While this building was a sort of "standing joke" and had even been characterized by an investigating committee as "a disgrace to the Commonwealth", its passing not only caused considerable inconvenience and loss, but is to be regretted as a matter of sentiment. It was the first of the College buildings to be erected for class purposes; it had been used by probably every four-year student throughout the history of the institution; and it was in this building where one of the great teachers of the College, Dr. Goessmann, did his work and where he trained some of the ablest and most useful of the alumni of the College.

Fire Protection.

Beginning some fifteen years ago there was instituted a system of fire protection at the College which it was hoped would prevent serious fires. Two night watchmen each make three or four rounds of the entire property each night; hand fire extinguishers are found on every floor of every building; the College itself possesses some 1050 feet of hose and two hose carts, one of which has a forty-gallon chemical tank. When the town of Amherst purchased its fire truck some eight or ten years ago, the College contributed a thousand dollars on condition that the truck should be equipped with a pump, the fear being that for some of the buildings the existing water pressure is not sufficient. Curiously enough the first test of this pump after it was purchased, was made on the chemistry building itself and the stream was thrown many feet above the roof from the lowest point surrounding the building. In addition to these precautions one of the best fire chiefs in western Massachusetts inspected the institution and made a number of suggestions concerning protection. After the chemistry fire the Department of Public Safety was asked to make still another survey and the State Fire Marshal himself as well as one of his deputies has gone over the institution. The final recommendations from this Department are not yet at hand but will be submitted as soon as they come to our hands.

Legislative Appropriation in 1922.

The legislature of 1922 provided special appropriations for the undertaking of three major projects, namely, the construction of a new chemistry laboratory, improvements at the power plant, and the purchase of the "Brooks Farm."

The new chemistry building is in process of erection and it is hoped it will be ready for occupancy by the beginning of the next fall term. The reduction of the requested appropriation by $50,000 necessitated a severe cut in equipment and some changes in the building. We are to have at last, however, a thoroughly modern and well built chemistry building, substantially fire proof, well arranged, and planned for expansion. When the building is completed a full description will be recorded.

The main improvements at the Power Plant made possible by the Legislative appropriation of $63,000 are: 2 405 horse power Heine boilers with equipment, including stokers, feed pump, and water heater; 1 300 kilowatt generator and turbine.

The acquisition of the Brooks Farm is particularly fortunate at this time. Owing to the erection of Stockbridge Hall, Flint Laboratory, Abigail Adams House and

the chemistry laboratory, serious encroachments in recent years have been made upon the test plots of the Experiment Station; furthermore the institution has not had suitable land which it could devote to experimental work in tobacco and onion problems, which have in recent years brought serious losses to farmers in the Connecticut Valley. The Brooks farm has been designated by the Trustees as the "William P. Brooks Experimental Farm" and will be used primarily for the purpose of research.

Gifts to the College.

During the past year three bequests of note have been made to the College as follows:

I. "Massachusetts Agricultural Society Loan Fund" of $500.

The purpose of this loan is to assist students, with preference for those planning to pursue agricultural work, to pay their college expenses.

II. Gift of $10,000 from the Bay State Agricultural Society, on the following terms:

"The Bay State Agricultural Society gives to the Trustees of the Massachusetts Agricultural College the sum of $10,000 and some $500 accumulated interest, to be held by them and to be known as the J. D. W. French Fund.

"It is our desire, as Mr. French was especially interested in Dairying and Forestry, that the Trustees use the income from this fund, so that in their judgment it will do the greatest good to students in dairying and its allies, also Forestry, either as scholarships, loans, or prizes. We should prefer, however, that when it seems most advisable, the income be used to help pay the expenses of a judging team to go from the Massachusetts Agricultural College to the National Dairy Show or National Live Stock Show."

III. Land from the Cornelia Warren estate at Waltham, including approximately 54 acres and certain farm buildings. Because of the advantageous location of this land as well as its adaptability for experimental work, and after careful consideration by the Trustees the conclusion has been reached that the interests of the market gardeners will be better served by disposing of the present Market Garden Field Station and equipment at North Lexington and re-establishing the Station at Waltham. Consequently a bill has been submitted for consideration by the forthcoming legislature authorizing the Trustees to dispose of the Market Garden Field Station at North Lexington with the understanding that the work will be re-established at Waltham.

Enrollment of Students.

In courses of Collegiate Grade: This autumn the registration of students in work of collegiate grade is 537, approximately the same as in 1921. The entering class numbers 187 as compared with 162 of a year ago and 135 of two years ago. Owing to the large number of last year's freshman class who failed in their studies the present sophomore class is unusually small. The number of graduate students is approximately the same as last year, as is also the number of special students. The total number of women students is 49, twenty of whom are entered with the freshman class. Of the 32 girls who were enrolled in the four year course of a year ago but 19 returned this autumn. Of the remainder some failed in their college work, but the majority transferred to other institutions in order to secure training in departments of work not offered at this institution.

In the Two-Year Course: There is a decrease in the enrollment of Two-Year students. In 1920 the enrollment numbered 277, in 1921, 293, and in 1922, 257. Instruction in "unit" courses to Federal Board students has been discontinued, it now being the policy of the Federal government to centralize instruction of this character in fewer institutions, each caring for a larger number of students than formerly.

In the Summer School and Other Short Courses: The Summer School of 1922 had an enrollment of 186 students. This was smaller than in the preceding two years, due to the fact that the Summer Training Courses organized by the Department of Education were this year given at the North Adams Normal School.

Total Enrollment: The total enrollment this autumn is 803, of whom 537 are enrolled in work of degree grade and 266 in the various short courses. During the year the total number of students registering at the College, including the classes graduated in June from the Two-Year and Four-Year Courses, has been approximately 1,300. (For details see pages 30, 31.)

Attendance at Agricultural Colleges.

Recently statistics have been gathered listing the attendance at the agricultural colleges of the country during the past three or four years. It was well known, of course, that the war practically closed our colleges for all real college work. But since the war there has been a tremendous influx of students into many of our colleges. However, nearly every agricultural college in the country shows a decrease of attendance during the past three years, in some cases amounting to a loss of a third. Our own College has just held its own during this period with respect to four year students, and inasmuch as each freshman class has been larger than the preceding one, it would appear that we are again on the upward curve. Probably the agricultural depression in New England is felt somewhat less than it is in the great agricultural areas where conditions are such as to discourage young men training themselves for practical agricultural pursuits.

Review of the Year in Academic Departments.

In June there was submitted to the faculty and alumni a report on the course of study made by a committee appointed for this purpose by the Associate Alumni; the chairman of this committee was Herbert J. Baker, 1911, Director of Extension Service in Connecticut. The committee consumed nearly a year in its investigation and made a careful inquiry among alumni and former students as well as the faculty and undergraduates. The report was one of the most comprehensive studies which has been made of our curriculum problems and called to the attention of the faculty and alumni many fundamental problems which confront not only our institution but probably every institution as well. The report met with general favor among the faculty and as rapidly as possible the principal recommendations will be put into operation.

The work of the freshman year was modified for the class entering this autumn. Beginning with this class also the so-called M. I. T. system of evaluating credits was adopted. It is proposed to make this plan of evaluating credits applicable to all future classes entering the College; also to gradually revise the course of study as the class entering in 1922 advances toward graduation; such a procedure will avoid a general reorganization of the curriculum and the confusion attendant thereon.

During the year, Dr. Alexander E. Cance, Head of the Department of Agricultural Economics, spent considerable time in Washington at the request of the Secretary of Agriculture to assist in the Agricultural Conference called by President Harding and to advise relative to the organization of research work in the Federal Bureau of Markets.

From an address recently made by Professor H. B. Dorner, Head of the Department of Floriculture at the University of Illinois it appears that the Department of Floriculture at this institution is the oldest separate Department of Floriculture in the United States; that it ranks third in the amount of glass used in floricultural work, being surpassed by the University of Illinois and Iowa State College; and that it ranks third in amount of funds appropriated for floricultural work, being exceeded by Cornell University and the University of Illinois.

The laboratory space available for the Department of Horticultural Manufactures is so restricted that this last year it became necessary to place a limit upon the number of students electing courses in this Department. The relief which will be secured by a laboratory for this Department is greatly desired both by students and members of the Department.

The Infirmary.

Dr. Marshall, who has charge of the infirmary, again calls attention to the present inadequate facilities afforded by the present infirmary accommodations and says in part:

The quarters are inadequate. I sincerely and fervently hope some way may be found to provide the main hospital. The number of patients in sickness other than communicable is growing, each year making a continuous demand upon our facilities. Further, these wards we now have or cottages designed for infectious diseases were never intended for permanent dwellings for nurses or living quarters.

The coming of young ladies to the institution has brought new difficulties, for the two sexes cannot be handled together with economy and satisfaction in the present cottages. When some drastic epidemic, as the influenza, comes, I dread to think of what may happen. If death occurs to a sick student lodged at Draper Hall or elsewhere we are likely to be blamed for years after. *Some action is very much needed.*

SOME IMMEDIATE PROBLEMS.

For some while it has been my custom to treat in this annual report some one outstanding theme concerning College policy or need. This year there is no one subject that seems to call for major discussion; on the other hand we are facing a number of questions of considerable consequence. As briefly as possible, I wish to call some of these to your attention.

Administrative Relations.

You will recall that I appeared in August, 1921, before the Commission on State Administration and Expenditures and made a frank statement concerning the operations of the present laws as they affect the College. We all hoped that the Commission would make recommendations which, if enacted into law, would give us substantial relief, and it was a matter of great regret that this did not happen. The present plan of control, as applied to an educational institution, is based on a fundamental fallacy, namely, that centralized control of expenditures secures greatest efficiency. We do not ask to be relieved of overhead restraint. We have never even suggested that we be free from responsibility to the Legislature. We do ask for a set of laws and regulations that will give us complete responsibility of management, under such audits, reviews, inspections, or checks as are thought necessary both to the public good and to our own effectiveness.

"A State University."

The State Commission on Technical and Higher Education visited the college on November 15, spending the entire day here. We outlined to the Commission the present agricultural work of the College, indicated the importance of developing the institution more completely as a "food-supply college", and stressed the wisdom of conserving and promoting these two aims of the College even if enlargement of scope in other fields might eventually seem wise. We cannot, of course, anticipate the report of the Commission, but it is obvious that if there is to be in Massachusetts any increase in facilities for higher education at public expense, the policy and probably the scope of the College will be markedly if not profoundly affected.

Scholarship and Student Activities.

A committee of the Alumni, a committee of the Faculty, and a committee of students considered last year the whole problem of "student activities", and their report is now under consideration by the Faculty with reference to the possibility of definite changes in some of our plans. Most teachers probably have a feeling

that athletics and other student activities are overstressed in these days. Possibly the truth is not that too much time and thought are given to these matters, but that not enough time and enthusiasm are given to scholarship. With most students there is probably a good deal of time now wholly wasted, going neither to the activities on the one hand nor to the studies on the other.

Interchurch Student Secretary.

We all admit the importance of religious education, and yet we find it difficult to agree upon a plan which will be effective and still not offend religious beliefs or differences. This, of course, is especially true in a state institution. For many years now our system of morning chapels, weekly assemblies, and the plan of Sunday chapels for a part of the year voted by the student body, seems to have worked very well. A student is excused from all of these exercises if his request is based upon religious scruples. However, it has long been felt that this system was not enough, and various efforts have been made to provide more fully both religious education and counsel. Many students these days are puzzled concerning religious questions, and they need a friendly, wise man whose business it is to try to help them. Various national church boards finally agreed to assist financially, provided funds could be raised from other private sources, such as students, alumni, and friends of the College. This has been done and the Advisory Board employed Rev. John B. Hanna to become the Interchurch Student Secretary. Mr. Hanna entered into his task with great enthusiasm and the plan gives promise of being a great success. It involves the College in no expense.

Course of Study.

Already, in the review of the year, reference has been made to the report of the Alumni Committee on course of study and as indicated steps have already been taken to carry out some of the recommendations. It is slow work revising a course of study. It must be done cautiously. There are many practical details to reconcile as well as fundamental considerations to be agreed upon, particularly at the time when educational principles are under sharp discussion with wide divergence of views, is it important to make haste slowly.

It is sometimes thought that State supported institutions may well have lower standards of scholarship than endowed institutions. I do not agree. It should be the policy of a State supported institution to give as wide an opportunity as possible for students to enter, but the standards of work within the institution itself should be high, if not exacting. At any rate, the diploma and degree from a State institution should certify quite as much in the way of thoroughness and quality of work as a similar degree from any other institution. In connection with this problem of course of study, I may say that personally that I have had a growing conviction that the first year of attendance in the four-year course should be made a thoroughly effective year of testing for the student. The course should be required in all particulars and it should be a time of adjustment for the student in order that he may make up deficiencies, choose his major line of study, learn how to master his lessons, to make and maintain his personal program and schedule, and in other ways to orient himself. He should have the best of teaching and sufficient personal counsel and guidance to lead him, if possible, to "find himself". No student should be admitted to work in the upper three years unless he gives promise of reasonably successful prosecution of the work there required.

Graduate School Problems.

A special committee on the work of the Graduate School was appointed last spring, and the graduate staff has accepted their report. No radical changes are made. One of the two principal recommendations looked toward the broadening and liberalizing of the course of study for graduate degrees, thus preventing too narrow specialization; and the other accepted a policy of granting special degrees

for rather specialized professional work: we already give, for example, the degree of "Master of Landscape Gardening." It is proposed to offer these special professional degrees only as there seems to be a rather clearly developed recognition of what is essentially a new profession.

Alumni Endowment Committee.

Before the war a committee of alumni was appointed to consider the question of private gifts to the institution. The committee has recently been reconstituted with Professor C. S. Plumb '82 as chairman, and plans are under way for rather thorough organization of the work of pressing the claims of the College upon individuals. There is no reason why private gifts coming from people interested in education and especially in agriculture, should not be available. A growing educational institution always has needs far beyond any possible source of income. Moreover, there are always in a State institution many demands which it is difficult to supply from State funds, sometimes because they are insufficient, sometimes because there is a prejudice against such expenditures. Moreover, as a college of agriculture like any other institution renders such a fundamental service to the welfare of society, there is the same argument for private gifts as there is on behalf of the endowed institution. It is believed that many individuals quite outside of the alumni body, once they understand the work and needs of an institution like ours, may be persuaded either directly or in their wills to make substantial gifts to the institution.

Professional Improvement.

I trust that your Board of Trustees may soon announce a plan for encouraging the professional improvement of members of the staff. We have here a problem of first importance, not only because we need to give the members of the staff every chance to keep growing, but because with the scale of salaries as it is we must give some measure of real and substantial encouragement. Details of such a plan are of importance, but the main thing is to have a general policy in operation so that the staff may make their own personal plans for taking advantage of it.

Town Representatives.

Two years ago we inaugurated a plan of having a College representative in each town and city of the Commonwealth. At the present time we have two hundred and sixty-four. These men are, of course, serving without any perquisites and are rendering a real service to the College. We send them monthly bulletins of information. We ask them to let us know about prospective students, to distribute publicity material now and then, and this winter we hope to bring them together into county groups, in order to tell them more about the College. Many of these town representatives are alumni of the College.

Administrative Organization.

The administrative officers of the college are now considering a long list of suggestions looking toward the need of changes of organization of the institution on the administrative side. We are endeavoring to determine the function of different bodies such as the faculty, administrative officers, committees, etc., as well as to work out a plan of operation that shall minimize machinery while at the same time giving a business-like and effective administration.

Self-study of Expenditures and Questions of Reducing Costs.

There is little doubt but during the past few years the per capita cost of instruction at the College has increased. Some of this is due to higher prices for supplies as well as an increased use of supplies. The College coal bill for example, in 1913 was $20,000, in 1923 it is estimated that it will be $72,000. Increase in salaries, thoroughly justified, nevertheless means increased per capita cost of instruction.

The appreciably smaller attendance in four year work since the war is one of the material causes of this increase. We of the faculty are not unmindful of this situation and not only are we endeavoring to be as economical as possible, but material has been gathered in a sort of self-study of the institution which we hope may be useful in discovering opportunities for still further savings without impairing the quality of the work.

The Building Program.

Until the future policy of the College and its place in the system of education in the Commonwealth is more fully determined it may not be possible to carry out the plan which we have discussed in former years of announcing a long-term building program. But we do need to consider at this time what shall be the next one of the larger buildings which we shall ask of the Legislature. There seem to be three of particular importance, namely, library, gymnasium and armory, and dormitories. I have taken occasion to sound alumni sentiment and find it somewhat divided, with the majority perhaps in favor of dormitories as the first need. Students favor the gymnasium. Personally I favor the gymnasium.

Massachusetts Food Supply Program.

In my report for 1917 I called attention to the growing conviction on the campus that the approach to the problem of agriculture must be made from the standpoint of the consumer, and that consequently not only would our policy be affected by such considerations but that also this institution was particularly well equipped and must hereafter consider it its duty to become essentially a food supply institution. Evidences of the soundness of this decision continue to multiply. The United States Department of Agriculture has recently instituted rather thorough-going studies of consumption as well as distribution. The great farmers' organizations are at present particularly concerned in economical methods of distributing farm products, and manufacturers are beginning to show concern over the place of food supply in their problem. Nearly two years ago a campus committee was organized to study this whole question by making an analysis of the problem itself and then indicating what this institution can and should do in the premises. I trust that the committee report will be made available during the coming year. I regard this move as one of the most significant that the College has ever taken, not only from the standpoint of increased possibilities of usefulness to the Commonwealth, but because of enlargement of scope and breadth of the work of the College itself.

LEGISLATIVE BUDGET, 1923.

Projects for Permanent Improvement.

Chemistry Laboratory, $150,000. — The Legislature of 1922 appropriated $150,000 for the construction and equipment of a Chemistry Laboratory with the understanding that an additional appropriation of $150,000 would be made by the Legislature of 1923. On this basis, contracts have been awarded for the construction of the laboratory, and the work is at this date well advanced.

Laboratory for Horticultural Manufactures, $38,000. — The importance of utilizing various by-products of the farm which formerly were wasted, such as fruit and vegetables, was emphasized during the war, and under the direction of Prof. W. W. Chenoweth of this institution farmers came to see whereby this saving could to advantage be made permanent. In order to give adequate instruction in the preservation of fruit and vegetable products, a new laboratory building is essential. The plans provide for a one-story building of inexpensive construction, which will furnish laboratories for the various phases of this work.

The pressing need for this building is now generally understood. However, some of the principal considerations may be recapitulated as follows:

1. The department of horticultural manufactures now has its work widely distributed in four buildings, viz. Flint Laboratory, Wilder Hall, French Hall, and a

workshop on the hill near the cold storage plant. This wide scattering of the work is obviously very detrimental to it.

2. The principal teaching is done at Flint Laboratory in rooms which were designed for the use of the dairy department. The dairy department needs these rooms and would like to see the department of horticultural manufactures cared for elsewhere as soon as possible.

3. The present quarters are entirely inadequate for the teaching work. On account of the limited space the department has been compelled to refuse admission to numbers of students. This is perhaps the only department in the institution which has been compelled frequently to refuse admission to students on account of lack of space. All the teaching could be much better organized and more efficiently conducted in a new building designed for this particular work.

4. It is highly desirable that vigorous research work be undertaken at the earliest opportunity in the field of fruit and vegetable preservation and the manufacture of by-products. A strong demand exists for this work among fruit growers, but the subject is equally important to all consumers of food in Massachusetts.

5. The department is now carrying on important extension work, but these extension projects need to be strongly supported by effective work at the college, and especially by well-directed research work.

6. The Massachusetts Fruit Growers' Association, the Boston Market Gardeners' Association and other organizations have urgently requested this proposed building. This specific demand from the fruit growers and vegetable growers should be squarely met.

Tunnels from the Power Plant to Stockbridge Hall and to First Steam Pit South of the Power Plant, $39,250. — The principal argument advanced in support of this project is the recommendation made by French and Hubbard, Engineers, who recently made a study of the present heating plan and future development for the same, "that a tunnel be constructed to Flint Laboratory and Stockbridge Hall and the piping arranged so that exhaust steam can be used in these buildings. We are firm believers in tunnels for steam mains of this kind, and believe that when it is necessary to rearrange the underground piping, that tunnels be constructed. We would recommend this both for economy in the long run and on account of convenience in repairs and pipe insulation."

At present none of the underground steam lines are enclosed in tunnels. The result is a high cost of maintenance because of the excessive radiation and because of the difficulty in locating and repairing leaks. Also, at present, the maximum use is not made of exhaust steam; this latter difficulty would be met by the project here outlined.

Development of the Market Garden Field Station at Waltham, $25,000. — The trustees of the will of the late Cornelia Warren have offered to the college about fifty acres of land located near the Clematis Brook railroad station in Waltham. This area is admirably suited for experimental work with vegetable crops. There are about twenty-three acres of level, uniform, well-drained, upland soil naturally much better adapted for experimental purposes than is the present area at North Lexington; and about fifteen acres of peaty, swamp deposit, typical in many respects of the area of wet land now being reclaimed in many different parts of the State, primarily as a health measure, but potentially of great importance to agriculture.

In addition, there is the old farmhouse, which may be remodeled to serve as living quarters for the Field Station foreman, and likewise as administrative headquarters for the plant. There are a number of other smaller buildings, some of which can be utilized, others of which may have to be wrecked.

The opportunity for more thoroughgoing investigational and demonstrational work in vegetable growing is so apparent that the trustees of the college have accepted this gift. The sum of $25,000 is needed to cover the cost of the initial equipment at the new Field Station, in order that work may be started in the late fall of 1923. This appropriation is needed to erect a thief-proof wire fence around the plant, to care for the remodeling and moving of one of the smaller buildings now on the place to serve as service headquarters; to build a greenhouse range and heating plant; and to make preliminary repairs on the house and other build-

ngs. In addition, small appropriations will later be needed to care for the draining of the swamp and to make other improvements.

By vote of the trustees a bill is being introduced into the legislature authorizing the college to sell the North Lexington plant. It is expected that receipts from the sale of this plant will be approximately $20,000. In effect, therefore, the initial cost to the State of the much larger plant at Waltham, a total of fifty acres as against twelve acres, with increased opportunity for effective work, will be approximately $5,000.

Women's Gymnasium, $15,000. — With the number of women students now attending the college, a gymnasium is becoming constantly more imperative. Lack of gymnasium facilities for girls is in some respects a more pressing problem than lack of similar facilities for men students because for the latter there can be organized outdoor sports of a wide variety. An appropriation of $15,000 would provide a frame gymnasium for women students which would meet our requirements for a number of years.

Addition to Rural Engineering Shops, $15,000. — The demand for instruction in Rural Engineering has greatly increased during the past four years. The Two-Year students in particular elect this work in large numbers. In view of the fact that such a large proportion of the instruction is given in laboratories, it is essential that in the interests of economy as well as convenience larger laboratory facilities be provided. In the opinion of the head of the department, the present laboratory and shop should be double in size; the appropriation here indicated would provide for an increase of 50% in the floor space of the existing facilities. This additional space would be used for instruction in the care of motors, farm machinery and in the making of concrete, and for the display of farm machinery and other equipment.

Roads, $8,000. — The college is responsible for the upkeep of approximately two miles of road running through its grounds, — a road which is used constantly by the public. Over a section of approximately two thousand feet of this road all the coal which is used at the college is hauled by truck. About half this section was rebuilt with thin macadam several years ago; it is now, however, in poor condition and accordingly no portion of the roads passing through the campus is of first class construction. Negotiations have been entered into with the State Highway Department relative to a plan of co-operation between that department, the town of Amherst, and the college, whereby different sections of the roads passing through college grounds as well as certain roads approaching the college may be used as demonstrations of various types of road construction. In order that a beginning may be made on this test and also that a portion of the road bearing the heaviest traffic may be placed in suitable condition the sum of $8,000 is requested to be expended during the ensuing year.

Tool Sheds and Garage for Division of Horticulture, $6,000. — At present there is no garage in which to keep the service truck operated by the grounds department; it is stored in a shed with other equipment under conditions which are unsafe from the standpoint of fire risk. Furthermore, there is not sufficient shed room to house other equipment such as wagons, sleds, and plows which are used in the farm operations. If the present tool house were rearranged as is contemplated, the work of the service department could be carried on more satisfactorily and economically. The plan proposed provides for the rearrangement of an existing building in order to provide a larger storage room and for the equipment of a carpenter shop, blacksmith shop, and an automobile repair shop. It would also provide more adequate facilities for the storage of tools and the installation of a suitable washroom for the workmen.

Live Stock Replacement, $5,000. — It is necessary to replace a certain number of live stock each year. Unless this is done, the college herd will deteriorate and the educational effectiveness will thereby be greatly lessened. A considerable amount of live stock is sold each year, but in view of the fact that all receipts of the college are turned into the State treasury, the funds thus derived from the sale of live stock cannot be used for the purchase of new animals. As a result of this situation which has continued for four years, a substantial sum of money should be expended

immediately in this department, and $5,000 is requested for such expenditures during the coming year.

Calf Barn, $5,000. — This appropriation is requested in order to construct a wing to the south of the present hay barn and of the same dimensions as the present young stock stable, but fitted with pens for a calf barn. This addition to the barns is considered essential for the proper care of the large number of young stock which is carried.

Improvements at the Tillson Farm, $5,000. — Following out the project submitted a year ago and for which the legislature of 1922 made an appropriation of $5,000, a second appropriation of like amount is requested to further the development of Tillson Farm as a poultry plant for experimental use. This last year four unit houses, 30 x 30 feet, were built, a water supply was developed, and the old cellar on the place was repaired and roofed over to serve as an incubator cellar. The appropriation here requested is to cover the cost of the station requests for living quarters for the foreman of the experimental farm, for feed room, shop, operating room, office and storage; and for a laying house for pullets, the total cost of these being estimated at $5,000. Since there will be at various times from 1,500 to 4,00[illegible] birds kept on the farm, the necessity of having the foreman resident at the plant wil[illegible] of course be apparent to all. This appropriation will not cover all of the require-ments of the new plant, but will put it in condition for effective use this coming year

Superintendent's Cottage at Farm, $5,000. — The barns where the sheep an[illegible] swine are housed are located a considerable distance from the main stock barns The shepherd who has charge of the sheep and swine lives a mile distant. Fre-quently, during the winter months especially, the caretaker should be sufficientl[illegible] near the stock to enable him to visit them late at night, early in the morning, an[illegible] if necessary, frequently during the night. This close care can be insured only i[illegible] case the superintendent lives near the barn.

Fencing Fruit Plantations, $3,000. — Because of lack of funds, the fencing o[illegible] the large fruit plantations owned by the college has been deferred. As a result, [illegible] good deal of fruit is stolen each year in spite of the fact that the orchards are pro-tected by a watchman during the season when the fruit is ripening. The expendi-ture of the sum here indicated would seem to be justified on the grounds of econom[illegible]

New Walks, $2,500. — For a number of years practically no money has bee[illegible] spent in the construction of new walks or renewing old walks. In order to mee[illegible] the more imperative demands for walk construction a sum of $2,500 is requeste[illegible] for this purpose for the ensuing year. With this appropriation it is proposed t[illegible] construct a cinder walk 6 ft. wide from the Physics Building to the East Exper[illegible] ment Station, a distance of 960 ft. estimated at approximately $700. It is als[illegible] proposed to re-lay a strip of worn out tar walk and substitute a granolithic wal[illegible] from the Drill Hall north to South College and North College, length approx[illegible] mately 800 ft., width 6 ft. and estimated to cost $1,800.

Grading and Draining Addition to Athletic Field, $2,500. — It is planned to exten[illegible] the present athletic field south on existing college property a distance of 300 fee[illegible] This will make possible the installation of several tennis courts, and the extensio[illegible] of the present recreation field to accommodate a much larger number of studen[illegible] than is now possible. The entire project cannot be completed with an appropri[illegible] tion of $2,500 although this amount will meet the immediate requirements.

Land for Cranberry Station at East Wareham, $1,000. — An appropriation [illegible] requested of $1,000 for the purchase of about sixteen acres of land contiguous [illegible] the Cranberry Station at East Wareham, for the purpose of providing opportuni[illegible] for increase in experimental work with blueberries, for variety testing of cra[illegible] berries, and other experimental work of a similar nature. A part of this sixte[illegible] acres is adjacent to a pond, and is a favorable site for the construction of a seco[illegible] experimental bog. Another part is well suited to the extension of the commerci[illegible] blueberry work, while the remaining area is needed both for straightening t[illegible] boundary of the present plant and to serve as a source of upland peat, sand, a[illegible] fuel.

KENYON L. BUTTERFIELD,
President.

REPORTS OF OTHER ADMINISTRATIVE OFFICERS.

Report of the Acting Dean.

On account of the absence of Dean Lewis it becomes my duty to present the Dean's report for the year. Dean Lewis was granted a six months' leave of absence beginning October 1. He has used part of this time for a much needed rest. Recently he has been studying administrative practices in other state institutions. The last half of his leave he intends to spend in travel and study abroad. He is expected to return in April, 1923.

During the first part of the period this report covers Dean Lewis was Acting President. His duties demanded practically all the time and energy he could command, but his helpful experienced counsel made my work as Acting Dean considerably easier.

The year opened auspiciously. We began by getting our students into classes without delay. In this matter the Supervisor of the Schedule, Professor Julian, rendered invaluable assistance. Text-books were on hand, section lists posted and schedules made up with dispatch.

Very soon after the opening of college a Freshman teacher's meeting was called at which time attention was directed to special cases of Freshmen and suggestions as to general procedure were pointed out. Possibly never before did a term's work start off more promptly and run more smoothly. The result was very few failures at the end of the first term.

However, during the second and third terms the number of failures showed a marked increase. One reason for this increase may be traced to the effects of the "rushing" season. This came at the beginning of the second term, immediately upon the return of the students from their Christmas vacation. Although the season was not a long one it was sufficiently intense to unbalance the regular routine and the setback suffered by many Freshmen and even by members of the other classes was never fully overcome. So harmful and unsatisfactory were the results that it was decided to change the time for and the length of the "rushing season," by confining it to the first three days of the fall term. This new plan seems to work well and is likely to become our permanent practice. Certainly satisfactory class work and "rushing" cannot be carried on at the same time.

The Freshman advisory work was continued during the first term in accordance with the practice inaugurated several years ago. In this work I was assisted very ably by Professors Parker, Rand, Moore and Julian. Acting on the principle that gradual release from authoritative supervision must prepare the student for self-supervision, the efforts of the adviser in behalf of his advisees were materially reduced during the second term and almost abandoned during the third term. Of course counsel, sympathy and friendliness towards them were never relinquished.

While a start has been made there still remains much to be done to give our new men the right point of view as to relative importance of so-called extra curriculum activities and studies, respectively. When parents back home often have the wrong viewpoint, it is not surprising that a large number of our incoming students should have the wrong attitude.

Anything that we can do by better teaching, closer contact, and wiser direction will not be amiss because it will tend to correct those tendencies and viewpoints in students which, if allowed to grow unnoticed, will sadly hamper, if not entirely annul, the effectiveness of what the college should give to every student. A contented student usually does good work — he profits by what the college has to offer. Hence our interest in a student must be broad enough to concern itself with the problems of housing, feeding, class relations, habits of study, regularity, punc-

tuality and effective sympathetic teaching. Too much care cannot be had in the selection of teachers of Freshmen.

During the year we lost the services of our head clerk, Miss Gertrude Hollis, who was connected with the Dean's Office for more than two years. She was a faithful and careful worker and her resignation meant a distinct loss. To fill the vacancy caused by the resignation of Miss Hollis we were fortunate indeed to secure Miss Grace Gallond who came to us from the Dairy Department. By her tactful and thorough manner she has already demonstrated her fitness for handling the innumerable office details in a sympathetic and satisfactory manner.

No distinctly new policies were inaugurated during the year. Routine matters in connection with scholarship, class attendance, committees, adjustment of schedules and conferences with students on numerous and varied problems more than comfortably filled every available minute which I could command.

The practice of keeping office hours at the rooms of the Department of Education, State House, Boston, every Thursday, started last year by Dean Lewis, was continued and the large number of conferences sought by those interested in the college and the opportunities which it offers fully justify the expenditure of whatever time and money may be necessary.

In addition to the work in the Dean's Office I continued to carry my regula teaching schedule in the Department of Mathematics. This direct contact witl students in the class room is a real help to one who counsels and directs them i matters of scholarship and conduct.

The year's work was pleasant. To assist the students of slow mind, to encourage those who had a bad start, and to spur on the fellows inclined to loaf kep the duties sufficiently varied to make the work interesting. In my efforts I enjoye the almost unanimous co-operation of the faculty and splendid support from th student body.

Attendance records and scholarship reports as a general rule were sent in regularly. Such support must be whole hearted if the Dean's office is to function a it should. Every effort is being made to use effectively every report asked for Several changes in absence reporting which have a tendency to tighten up o attendance will be made this coming year.

William L. Machmer,
Acting Dean.

Report of the Director of the Experiment Station.

The year just passing has shown distinct improvement in the land equipmen of the Experiment Station, but no corresponding change in its human equipmen There has been increased realization of the fact that the starting scale of statio salaries, at least, has been and is too low to encourage men to either prepare fo or enter station work. It has not yet been possible to increase materially the scop of station work, so as to enable it to give more service in relation to the food suppl problem of the State. There has been but little change in the conduct of regulativ work.

Land Equipment.

The action of the last legislature in appropriating money for the purchase of th "William P. Brooks Experimental Farm" fills a need of long standing, and fo the first time gives to the Experiment Station land facilities for the investigati of problems of tobacco and onion culture as well as of other problems of impo tance to the State at large. This advance is supplemented by the offer of gift fro the trustees of the will of the late Miss Cornelia Warren, which places at the di posal of the Station, through the College, an area of about fifty acres of land situate in Waltham, and very well suited for experimental work on vegetable crops. Tw important soil types are embraced in this new area, and the location is in mar respects superior to that of the present experimental plant at North Lexingto Finally, the action of the Trustees in approving a plan whereby the College far may be used for certain types of experimental work gives a certain degree of ela ticity to the work of the Station which previously it did not have.

A Pasture Experiment Station.

These additions to equipment fill most of the larger and more important land needs of the Station. There remains, however, one most important item, — a Pasture Experiment Station. Good pasture has always been a mainstay to the dairy industry. When our pastures were in their prime they contributed very largely to farm production and family income. At present, however, they are rapidly going to decay, and becoming liabilities instead of assets. One reason for the ability of the Vermont dairy farmer to enter and successfully compete in the home market of Massachusetts farmers lies in the efficiency of his pastures. Of course, it may be that the problem cannot be solved economically, but not until every attempt has been made should the State give up this source of potential food. As soon as existing land facilities are organized on a research basis, the matter of securing land for work of this kind will be pressed. The proposed farm should be located either in the highlands of Worcester County, in the heart of its dairy section; or in the hill country west of the Connecticut.

The Human Equipment of the Station.

Unfortunately, progress in human equipment has not kept pace with that in land equipment. A year ago I specified five new positions, among all of those requested, as being essential for the economical conduct of work already under way. Not one of these requests has been granted. It is unnecessary for me to reiterate statements already made in support of plans presented. From the standpoint of institutional policy, however, it may be well to admit the fact that existing work cannot be efficient unless some of our departments are more adequately manned. We should not attempt to do some of the work which we are now doing unless we have some assurance that deficiencies in personnel may be remedied in the fairly near future.

The Salary Scale.

At the present time difficulty in maintaining personnel is being caused by the low salary offered as a starting point in station service. Agricultural research as now organized differs radically from the "agricultural experimentation" of an earlier day, and requires more intensively trained men. Research work in disease prevention is replacing that of disease control. Fundamental studies in animal nutrition are supplanting comparative studies in the characteristics and properties of feeding stuffs. Systematic studies in plant and animal breeding, in the light of the new science of genetics, are taking the place of the comparative breed and variety tests of former days. Because of these changes in the character of research work, more is now required of research workers, in the way of fundamental training, than was either necessary or possible in the earlier days of the experiment stations. Preparation for the work is a long and arduous task. It must be based on four years in regular college course, followed by the equivalent of three years in a graduate school. Interpreted in terms of human values, seven years of a man's lifetime must be spent in training before a man may be properly equipped to fill anything other than an apprenticeship position in the Experiment Station. Few men will be willing, and fewer still able, to undertake this training unless they feel fairly certain of suitable rewards. Our present starting point in the salary scale is so low that there is no encouragement for a man to either prepare for or enter station service.

Quite pertinent in this respect is a statement made a year ago by the Director of the Graduate School. He said, "Men . . . must be able to solve the problems satisfactorily and not dawdle over them because of lack of training and understanding. The limitations in training and education should never be regarded as an excuse." This statement should be accepted as a fundamental truth; yet in view of the low starting point of station salaries, it is difficult to see how these positions can serve other than apprenticeship functions.

The Food Supply Service.

During the year attention has been given to the problem of co-ordinating the station research work with the problem of the food supply of the Commonwealth. Analysis of this problem shows the following salient subdivisions:

1. Production on the farm.
2. Conservation and prevention of waste.
3. Transportation.
4. Storage.
5. Marketing and distribution of food products.
6. Utilization of food.

The service of the Station to productive agriculture represents its major service to date. It is not complete; but we can at least say that the machinery for giving full service, or as full as may humanly be expected, is in existence. In the problem of conservation of food already produced, the Station is just beginning to serve. The fact that during the past year thousands of gallons of milk were wasted because of lack of a market for this product in its fluid form; the fact that during the early fall countless bushels of fall apples were wasted because of glut in the market; the fact of waste of even such a staple product as potatoes through disorganization of the market indicates the need of fundamental service of this kind.

Notwithstanding this, our Department of Horticultural Manufactures has not yet commenced to function in a research way. The work on food preservation represented by certain fundamental studies in the Department of Microbiology, first initiated during the War, has languished because of lack of sufficient man power. These facts are cited simply to show the need of service and our inability to render it.

In the next three subdivisions of the analysis, *i.e.*, transportation, storage, marketing and distribution, the Station is just beginning to serve. It is probably true that economical transportation, modernizing of marketing and distribution methods, and the removal of storage from the speculative field to that of real economic service are as important to the food consumers of the State as is economic production on the farm itself. The matter of equipping the Station so as to undertake this basic work is second to none in importance.

No work has been done at the Station on the problems of food utilization or human nutrition. It may be an open question as to whether the Station is the organization to undertake this important work. I hardly care to discuss this at this time, other than to state that the problem is most vital to an industrial Commonwealth such as Massachusetts, far removed from supplies of raw materials and from the centers of food production.

Regulative Work.

During the year the law governing police control of animal feeds was amended so as to make this activity self-supporting. Operations under the poultry disease elimination law were radically changed, so as to secure better co-ordination of effort with the Extension Service of the College, and with the purpose of developing certain centers from which disease-free breeding stock or eggs for hatching might be secured. Of the fertilizer control law little need be said other than to point out the fact that the State is at present making a profit on something which should be no more than self-supporting. This was certainly not contemplated in the original law, as it was specified that any surplus over the cost of carrying on this regulative work should be expended in carrying out field experiments in the use of fertilizers. Under the present organization such margin is not available to the Station. During the year just past $13,000 were appropriated by the State for the police control work in fertilizers. The receipts from this service were $16,560. In my opinion

the existing law should either be amended so as to bring to the Station, to be expended as provided for in the original law, full receipts from this police control law; or rebate should be given to manufacturers for the difference between the actual cost of carrying on the work and the actual receipts.

SIDNEY B. HASKELL,
Director of the Experiment Station.

Report of the Director of the Extension Service.

Few changes in staff, and the steady development of projects have characterized the work of the past year, which has been the most satisfying since the war. This was true not only at the college but in the County Extension services also. Serious interruptions of work have been few. Conditions of the agricultural industry have been far from satisfying, although some groups have prospered. The rainy season injured many crops, and caused special problems to some, while it helped others. Wherever special problems in production or marketing resulted, special demands were made on the Extension Service to meet them. Few material changes have been made in projects and plans of work, and this is as it should be. Few pieces of project work can be completed in a single season. Emphasis may be shifted as one phase becomes the more important; but continuity is preserved. In the soils and crops project, for instance, much less time is given to promoting the use of certified seed potatoes when the use becomes more common, and more time is given to the care of the crop and to protecting it from disease. Demonstrations have increased in number, continuity, and teaching value. Relations with the Experiment Station work have continued most friendly, and have been developed to give greater values to extension teaching. Effective co-operation with the resident teaching staff continues. Mailing lists have been revised to eliminate duplication and avoid wastes. Many new publications have been prepared, and several older ones rewritten. Periodical publications have been prepared and mailed regularly. Over five hundred students were enrolled in correspondence courses. Very little was attempted in exhibits because of lack of funds. Extension schools followed the trend toward the short specialized school instead of the longer, diversified session. The rainy haying season reduced attendance at Farmers' Week, but the work done by the groups which gathered was more effective than ever. Camp Gilbert, for the county champions in Junior Extension work, was an unqualified success. The general camp for boys and girls who paid their own expenses was omitted for lack of funds.

The professional staff at the college numbered nineteen at the beginning of the fiscal year. Mrs. Ruth S. Reed resigned as Clothing Specialist, and Miss Marion L. Tucker was engaged to fill the position. Mr. Joseph F. Whitney, Specialist in Landscape Gardening, was granted leave of absence and left in the late summer for Europe for further study. Mr. Robert D. Hawley, who resigned in November 1921, returned in September of this year to his former position as supervisor of exhibits, extension schools, and extension courses at the college. No other changes have occurred in the specialist staff at the college. A number of changes in the secretarial and clerical staff have caused noticeable retardation of work, but with the close of the year the new staff-members are assuming their responsibilities satisfactorily.

The total professional staff in the counties has numbered approximately fifty. Two county agricultural agents and one assistant agent, two county home demonstration agents and two assistants, and one assistant county club agent have resigned during the year.

The financial support of extension work, both at the college and in the counties, has enabled continuance of work without much increase or decrease. County appropriations were in nearly all cases the same as for the preceding years. States Relations funds, assigned by the United States Department of Agriculture to

salaries in the counties and at the college remained the same. Regular Smith-Lever funds (Federal) reached their maximum under the law during the Federal fiscal year 1922–1923, and will hereafter remain constant, barring amendments to the appropriating act, or changes in the census return of rural population. Supplementary Smith-Lever funds were reduced in total, and may soon be entirely withdrawn. State appropriations enabled us to hold our staff, with no serious changes. The personal service item would have permitted more use of temporary help on extension schools and special projects, but a reduction of the appropriations for maintenance made it unwise to employ help for whose travel expense we had no adequate funds.

For a statement of the receipts and expenditures of the Extension Service at the College, may I refer you to the report submitted by the Treasurer of the College.

Detailed report on projects is not attempted here, but will be included in the report to the Governor in accordance with the requirements of the Smith-Lever Act.

The principal needs of the Extension Service for the coming year are maintenance funds to make more effective the work of the staff; specialists in crop protection, household management, rural engineering and animal disease control; ability to apply revenues to the costs of the projects in which they are earned; and a more liberal and dependable policy in the matter of out-of-state travel.

JOHN D. WILLARD,
Director of the Extension Service.

Report of the Director of the Graduate School.

A year ago the writer undertook to deal with "Fundamental Education" in graduate work. At that time he was conscious of certain forces operating in the general field of secondary and higher formal education to undermine not only fundamental education but also effective education of the formal nature. There are many of these forces which should be considered but in this instance it will be possible to study only one of several of these forces as an illustration for a group which is more or less conspicuous and pertinent at this time.

There has been developing a habit or a tendency in recent years to use certain euphonistic terms in a subjective and more or less detached manner. In the context the meaning is not decipherable, it is very vague and indefinite. There enters into them the spirit of innovation, of newness and of exploitation. The users seem to imply that the ideas have never before been conceived, while they are as old as history. To mention some of these terms will immediately provide the pabulum for energetic mental emissions. Some of the many are "personality," "service," "humanism," "Americanization," and "democracy." Most thinkers will grasp the significance from this limited enumeration.

It is not proposed to castigate such employment of these words or for a minut to assert that their implications, vague as they are, do not accomplish somethin of value, but as presented they serve merely as fireflies leading helter-skelter t light the wayfarer through the dense darkness of a labyrinthian life. At the sam time these notions are eating away the supporting structures of a basic educatio upon which progress depends because of their transcendent use without objectiv anchorage. Agitative propaganda of a purely abstract idea does irreparable injur when it conflagrates and lacks tangible realization as developmental actualitie When serious matters are demogogized to elicit popular support without havin accepted and tried mechanisms, such as are operable under existing conditions, t execute the task demanded, chaos and confusion are likely to follow and tru progress turns into reaction. Safe superstructures arise only on firm and satis factory foundations. History has repeatedly established this as a truism. It i the part of formal education to lead into the future through the established truth of the past and present or, in other words, base every step of advance upon th sure footing of the tried past or present. If science has contributed naught else, i has demonstrated this advancement to be correct.

Let us now develop our thoughts concretely by the study of the word "personality". When it is said by seemingly sane men that the "personality" of a teacher is all there is to teaching and an education and that subject-matter does not enter; when a student is led to believe that college life as lived in athletics and student activities is the all of a college career and that class studies have little significance; when public school pupils speak derisively of pupils who try to do their assigned duties and who do not spend their evenings in movies and dances, as "grinds", then there is no alternative in concluding that personality is either misunderstood or education is not a matter of individual study and effort but a monstrosity parading under false colors. These expressions, of course, must be obviously spontaneous, subjective and whimsical statements made without objective foundation and without due reflection. As such, too, they are often repeated and sent along floating upon the tide of verbal exchange without further consideration and without challenge. Many believe, few doubt and still fewer weigh the statements at all.

Personality has a very distinctive meaning and place. Its nature is dualistic. There is the mental self, the ego bound up with the consciousness that finds expression in "I am." In a sense it is an empty or evasive consciousness which man fails to determine fully and which yet exists for every human. Then there is a consciousness of things *extra-mental*, *extra-self*, or *extra-ego* or a consciousness which incorporates those things which exist beyond or apart from the *ego*. These *extra-impressions* reach the mind, perhaps the *ego*, through the sensations. They activate the mental mechanism which reveals itself in the consciousness *I am* and in turn which gives recognition to the consciousness of those things which have been received through the senses. In some manner the *ego* and the things received coalesce. The babe comes into the world with the mental self or mechanism ready for development. He starts with a mental capacity given by heredity and this mental capacity must be activated. He slowly responds to environment through his sensations. He notices the movement of his fingers, feels his toes, suffers pain, smiles when tickled and finally awakes to the fact that he is supported by a body. He becomes conscious of it. This process proceeds from a consciousness of self to companionship, to family, to those without his immediate environs, society, and later to community, state and nation. From the very beginning he has been accumulating experiences of the objective world in which he finds himself placed. These experiences create as he advances to manhood estate a more or less stable complex, subject to border variation, which represents his personality. Probably built upon an hereditary capacity is a self regulated functioning mechanism which secures its food or fuel or energy out of the materials with which the individual comes in assimilating contact and unifies these materials in accordance with his hereditary capacity, his environment and his real experiences into a *personality* —a personified synthesis.

If this is a personality, then constructive human effort is dependent largely upon the objective knowledge growing out of experiences and environment. It is made up of the objective world. If the hereditary mental transmissions were subject to the regulations of man, this aspect of the case would also enter, yet it would enter objectively and not subjectively. As it is there is an assumed simple recognition.

Whether a personality is attractive, appealing and possibly influential or inspiring to people at large, depends mainly upon the temperament of the individual. Some individuals, as thinkers, look beyond the temperament to the substance which makes for personality and are little influenced by it but there can be no doubt about the values of temperament. Based upon available present knowledge, however, it is probably safe to ascribe temperament to a purely psychological basis. The *brutish, snarling, cunning, snapping, bristling, creeping, barking, chirping, singing, frolicking, playful, purring* and *fawning* qualities are animal in origin. Man has them, too. While they influence personality they are not the substance of personality at all unless they become a part by objective incorporation through training.

Great personalities appear in history, biography, literature, science, art, business and in all lines of effort. They are found everywhere. The percentage in edu-

cational institutions is probably no greater than elsewhere. Young and adult minds are stimulated by them and draw from each those features which appeal and use them in producing a composite ideal of their own. But these personalities are formed largely out of objective or material matters and experiences which are utilized for constructive purposes. The wider these experiences or the greater the material experiences or education, the greater the personality provided mental capacity exists for receiving and creating unification or synthesis.

If this were not true, how would it be possible to account for self-educated men who have little if any personal instruction; for the student who gains success by application when his neighbor has the same personal contacts but fails; for the continuous mental development of men after they leave college when their real education seems to begin; for the values of mere reading which we all seem to accept? Why is that subject matter is undergoing division after division until specialization startles us? Why is it that pedagogic methods in subject-matter receive so much attention? Why is it that so many courses are established? Why is it that certain courses are considered necessary to attain a certain objective? Why is it that many men who are following specific professions or vocations regret that they did not pursue certain pertinent subjects while in college? Why are specialists employed? Do not all of these point to the very large part objective study exerts upon the experiences and environment of man, not only upon his value as a man but likewise his personality which is his larger and expanded self. Subject matter, of course, to be really significant and intrinsically worth-while must be intimately understood to be the basis for judgments and the material for reasoning out of which springs wisdom. Perception, understanding, judgments, reasoning and wisdom may be graphically represented as synthesized in personality.

Much could be gained were it within the scope of this article to take up the other terms for the benefit of assigning their present applications. To follow the concepts of service from primitive conditions to its present ephemeral agitative employment; to study the similarity of humanism as it existed in the days when it was proper to "do unto others as you would have others do unto you"; to parallel the liberty which was a branch of bigotry in the days of our Puritan fathers and the liberty which stands for Americanization, as it is measured by our "dollar" era; to understand a democracy which is idealistic as long as one's own ideas prevail and his faction is in control but when they do not prevail or control, blindness ignorance and class prejudice dominate — let us repeat, this would perhaps furnish enlightening and profitable study. The general difficulty seems to lie in a chimerical and evanescent usage of these terms and the detachment of the ideas from bases which have been already materially established by experiences. Accretive growth upon that which has been already created has been totally forgotten in an enthusiasm to start a consuming spiritual conflagration without any real substance to feed the flames. It would be a great advantage to recall that science moves ahead cautiously by building critically and experimentally upon the concrete experiences of the past and present.

The whole matter centers in following one of two paths in penetrating the future revolution or accretive progress. Education, on the whole, should be concerned with the latter only and its results, should furnish the stable basis of life and natural growth. Revolution, on the other hand, is an attempt to disorganize what already exists without gradual adjustment, to kill off our enemies which if carried to the extreme would reduce our population to a single individual and perhaps wipe it out completely, to reduce to primitive conditions which have been the product of centuries, and, in short, to create human anarchy. Everything that can be done to forestall unnatural or human turmoil and create civilizing stability should be the function of education, plodding and toiling at the foundations of society and not through its powwows.

CHARLES E. MARSHALL,
Director of the Graduate School.

Report of the Director of Short Courses.

The status of short course work during the past year has been very satisfactory from the standpoint of administration. Reasonable financial support has been granted by the legislature. The number of students registered in all courses is normal; the slight decrease in the entering class of the Two-Year Course for September, 1922, being due to the increase in tuition for non-resident students and to the elimination of the special unit courses for ex-service men. The percentage of non-resident students, exclusive of Federal trainees, for the entering class of 1921 was approximately fourteen; the percentage for the entering class of 1922 was nine.

Your attention is called especially to the following items in this report: —

(1) Recommendation for supervision of project work of students who have finished the Two-Year Course.

(2) Recommendation for the employment of a supervisor of oral and written English in the Two-Year Course.

(3) The need for housing of a part of the student group now enrolled in the college.

Courses Discontinued.

A. *Teachers' Courses.* — In 1918 the State Department of Education, at the request of some of the school superintendents in the western part of the state, offered at the Massachusetts Agricultural College during the summer professional courses in elementary subjects intended for public school teachers. The organization of these courses was in the nature of an experiment to determine whether or not there was such a demand for this type of work as to justify the State Department of Education making provision for it in some institution in Western Massachusetts. These courses were offered at the Massachusetts Agricultural College because the college was already maintaining a summer school. It was understood at the time that in the event there was a real need for this type of work the courses would be transferred to one of the normal schools in the western part of the state. The expense of the courses was borne by the State Department of Education; the college co-operated only in administration. The registration from the beginning demonstrated that there was a real demand. The total enrollment in all courses offered at the college was about 350. Approximately one-half of this number was enrolled in teachers' special subjects. In the summer of 1922 the courses were transferred to the normal school at North Adams. The college offered during the past summer its regular four weeks' summer school with an enrollment of 170 students. This number shows a slight increase over the enrollment in previous years in those courses offered by the college.

B. *Unit Courses for Ex-Service Men.* — The special unit courses for men disabled in the military and naval service of the United States offered by the college ever since the close of the war were discontinued June 30th, 1922. The Federal Government has now made such provision as to make this service of the college unnecessary.

Reorganization of the Two-Year Course.

The Two Year Course has been reorganized so that it is now possible for a student to devote the major part of his time to one of seven lines of work. These are animal husbandry, dairy, poultry, floriculture, horticulture, pomology, and vegetable gardening. The number of subjects that the student may take has been reduced to four. The student recites in each subject five times a week. The student chooses a group of subjects when he chooses a major, but once having elected that group there are practically no other electives. This plan has greatly reduced the cost of administration, and at the same time has made for greater efficiency.

Organization of New Courses.

Professor H. C. Judkins of the Dairy Department has organized four new short courses in dairy manufactures. These are given during the winter school. Each course continues for approximately ten days. The entire time of the student is devoted to some phase of dairy manufactures. The course for nurserymen organized last year by Professor Frank A. Waugh was promptly filled. The college is co-operating in the administration of this course with the New England Nurserymen's Association, the Massachusetts Nurserymen's Association and the Connecticut Nurserymen's Association. The course is limited to students who have already had some practical experience in nursery work. Plans are now under way for the organization of a similar course for the training of gardeners.

Supervision of Project Work and Placement Training.

The six months' farm experience required of all Two Year students has proved to be one of the most valuable features of the course. The purpose of the Two Year Course is to train young men and women for agriculture; for the ownership of farms rather than for paid positions on farms. The most critical time in the life of the student is when he first attempts to apply for himself in a farm business enterprise what he has learned. At that time he needs and should have the advice of an experienced man who is personally interested in his success. I would suggest a further extension of the plan now followed in placement training by the employment of a man whose particular business it would be to advise with and continue the instruction of graduates of the course who are going into farming for themselves. We need a part of the time of this man anyway for the supervision of the men during the six months of placement training. Mr. Viets, who has proved to be a very capable energetic supervisor, is unable at the present time to supervise the work as carefully as it should be during the time that the men are in the field.

Supervision of English.

The students in the Two Year Course should have some supervision in the use of oral and written English. I do not wish to have formal courses in English offered. This plan would not meet the needs. The students will, in my judgment, derive the greatest benefit if they are held strictly accountable in every class for written and oral work. We can accomplish this by employing a man whose particular task it will be to advise, correct, and, if necessary, discipline a student who does not make a reasonable effort to improve his written and oral English in all classes.

Housing.

I can but repeat at this time a statement I have made several times — that there is a real need for the housing of a part of the student body on the campus. I would suggest that if there be a dormitory it be for four-year men. I do not think our two-year men would take very kindly to dormitory life, but the dormitory would make other rooms in town available for the Two-Year students.

The following tables are included showing enrollment in the Two Year Course:

A. *Total Yearly Enrollment of Each Year Based on Enrollment from June to September.*

	1918.	1919.	1920.	1921.
Two Year Course	37	209	295	302
Ten Weeks' Winter School	91	63	112	83
Summer School	68	238	322	353
School for Country Clergymen	–	–	–	19
Vocational Poultry Course	5	13	19	26

B. Age Distribution of Two Year Students Based on Total Enrollment June to September.

Age (Years).	1920.		1921.	
	Number.	Per Cent.	Number.	Per Cent.
16	–	–	–	–
17	21	7.1	16	5.3
18	34	11.5	26	8.6
19	35	11.9	44	14.6
20	38	12.88	41	13.6
21	27	9.2	25	8.3
22	26	8.9	18	5.9
23	21	7.1	18	5.9
23	21	7.1	18	5.9
24	16	5.4	15	5.0
25 and over	77	26.1	99	32.8
Total	295	100.00	302	100.00

JOHN PHELAN,
Director of Short Courses.

TABLES AND STATISTICS.

TABLE I. — *Resignations.*

Position.	Name.
Instructor in Zoölogy	Charles H. Abbott.
Stenographer, Extension Service	Mrs. Esther W. Arp.
Assistant Research Professor of Chemistry	Carlos L. Beals.
Analyst, Control Service	Ethel M. Bradley.
Department Librarian	Margery Burnett.
Collector of blood samples, Poultry Disease Elimination	Ray A. Carter.
Stenographer, Extension Service	Hazel D. Chandler.
Professor of Vegetable Gardening	Arthur L. Dacy.
Clerk, Extension Service	Margaret G. Davidson.
Resident Nurse	Marguerite N. Davis.
Clerk, Extension Service	Florence E. Day.
Stenographer, Dean's Office	Mary A. Evans.
Stenographer, President's Office	Margaret Fish.
Research Professor of Poultry Husbandry	Hubert D. Goodale.
Instructor in Home Economics	Olga Grizzle.
Stenographer, Department of Rural Home Life	Mrs. Ethel L. Hammond (Carrier).
Clerk, Dean's Office	Gertrude E. Hollis.
Assistant Librarian	Florence B. Kimball.
Chief Clerk, Extension Service	Marguerite C. Leduc.
Instructor in Physical Education	Elton J. Mansell.
Bookkeeper, Treasurer's Office	Mrs. Gertrude L. Milne.
Professor of Veterinary Science	James B. Paige.[1]
Assistant Professor of Beekeeping	Norman E. Phillips.
Stenographer, Library	Frances Powers.
Stenographer, Extension Service	Mildred Putney.
Assistant Extension Professor of Home Economics	Mrs. Ruth S. Reed.
Bookkeeper, Treasurer's Office	Mrs. Ruth L. Rodwaye.
Instructor in Poultry Husbandry	William E. Ryan.
Analyst, Poultry Disease Elimination	Ann Smith.
Clerk, President's Office	Harriet A. Smith.
Stenographer, Extension Service	Mrs. Ruth M. Smith.
Stenographer, Poultry Husbandry	Mrs. Laura S. Tower.
Matron, Women's Dormitory	Mrs. Marie E. White.

[1] Died Oct. 5, 1922.

TABLE II. — *New Appointments.*

A. In the Academic Departments.

Position.	Name.	Degrees.
Assistant Professor of entomology	Charles P. Alexander	B.Sc., Cornell, 1913; Ph.D., Cornell, 1918.
Instructor in home economics	Mary A. Bartley	– – –
Instructor in physical education	Herbert L. Collins	B.Sc., Massachusetts Agricultural College, 1922.
Assistant professor of botany	William H. Davis	A.B., Cornell, 1912; M.A., University of Wisconsin, 1916; Ph.D., University of Wisconsin, 1922.
Instructor in zoölogy	Philip E. Foss	B.Sc., Bowdoin, 1922.
Instructor in microbiology	Mary E. M. Garvey	B.Sc., Massachusetts Agricultural College, 1919.
Field professor of teacher training	Charles W. Kemp.	B.Sc., New Hampshire State College, 1910.
Instructor in vegetable gardening	Grant B. Snyder	B.S.A., Ontario Agricultural College, 1922.
Instructor in poultry husbandry	Lewis W. Taylor	B.Sc., University of Wisconsin, 1922.

TABLE II. — *New Appointments* — Concluded.

B. In the Experiment Station.

Position.	Name.	Degrees.
Assistant research professor of chemistry	John G. Archibald	B.Sc., Toronto University, 1916.
Research professor of poultry husbandry	Frank A. Hays	B.Sc., Oklahoma A. & M. College, 1908; A.M., University of Nebraska, 1912; Ph.D., Iowa State College, 1917.
Assistant Research professor of avian pathology	Norman J. Pyle	V.M.D., University of Pennsylvania, 1918.

C. In the Control Service.

Analyst, Poultry Disease Elimination	Mildred H. Hollis	- - -
Analyst, Control Service	Frank J. Kokoski	B.Sc., Massachusetts Agricultural College, 1922.
Collector of blood samples, Poultry Disease Elimination	John J. Smith	- - -

D. In the Extension Service.

Extension professor of agronomy	John B. Abbott	B.Sc., University of Vermont; M.Sc., Purdue University.
Supervisor of extension schools and exhibits	Robert D. Hawley	B.Sc., Massachusetts Agricultural College, 1918.
Extension assistant professor of home economics	Marion L. Tucker	B.Sc., Columbia University, 1914.

E. Miscellaneous.

Resident Nurse	Anna M. Gabriel	- - -
Matron, Women's Dormitory	Mrs. Marie B. Marsh	- - -

F. In the Clerical Staff.

Position.	Name.
Clerk, Short Courses	May G. Arthur.
Clerk, Extension Service	Mrs. Teresa M. Binner.
Stenographer, Department of Rural Home Life	Nellie S. Carl.
Stenographer, Extension Service	Hazel D. Chandler.
Clerk, President's Office	Affie M. Cook.
Bookkeeper, Treasurer's Office	Marion B. Damon.
Stenographer, Extension Service	A. Iva Denny.
Stenographer, Extension Service	Jeannette M. Elder.
Stenographer, Extension Service	Laura Garnjobst.
Stenographer, Extension Service	Louise Leonard.
Clerk, Extension Service	Esther J. Lester.
Stenographer, Division of Horticulture	Hazel A. Longden.
Clerk, Department of Veterinary Science and Animal Pathology	Katharine M. Martin.
Junior Assistant Librarian	Katherine L. Powell.
Bookkeeper, Treasurer's Office	Mrs. Emma F. Sargent.
Clerk, Department of Dairying	Charlotte M. Sheffield.
Clerk, Extension Service	Dorothea E. Sinclair.
Stenographer, Department of Poultry Husbandry	Alice J. Twible.
Assistant Librarian	Bessie M. Weymouth.
Stenographer, Extension Service	Elizabeth A. Wheeler.
Stenographer, President's Office	Harriette C. Whitney.

TABLE III. *Speakers for the Year.*

A. *Speakers at Assembly for Year ending Nov. 30, 1922.*

1921.
Dec. 1. — Mr. Clifton D. Jackson, Springfield.
Dec. 8. — Dr. C. W. Pugsley, Washington, D. C.
Dec. 15. — Student Forum.

1922.
Jan. 4. — Mr. Lewis Hodous, Hartford, Conn.
Jan. 11. — Mr. James R. Marsh, Roxbury.
Jan. 18. — Student Forum.
Jan. 25. — Mr. Harry F. Ward, New York City.
Feb. 1. — Freshman–Sophomore Debate.
Feb. 8. — Mr. John L. Finley, Easthampton.
Feb. 15. — Prof. Raymond G. Gettell, Amherst.
March 1. — President Kenyon L. Butterfield.
March 8. — Hon. James J. Jackson, Boston.
March 15. — Student Forum.
April 5. — Prof. Curry S. Hicks, M. A. C.
April 12. — Mr. Joe Mitchell Chapple, Boston.
April 26. — Hon. J. Weston Allen, Newton.
May 3. — Prof. Paul Monroe, New York City.
May 17. — Student Mass Meeting.
May 31. — General Clarence R. Edwards, Boston.
June 14. — President Kenyon L. Butterfield.
Oct. 5. — Prof. Frank A. Waugh, M. A. C.
Oct. 19. — Mr. Roland D. Sawyer, Ware.
Oct. 26. — Senator George D. Chamberlain, Springfield.
Nov. 2. — Dr. Joel E. Goldthwait, Boston.
Nov. 9. — Prof. C. E. A. Winslow, New Haven, Conn.
Nov. 16. — Student Forum.
Nov. 23. — Dr. Homer J. Wheeler, Newton.

B. *Speakers at Sunday Chapel for Year ending Nov. 30, 1922.*

1921.
Nov. 20. — Bishop Thomas F. Davies, Springfield.
Dec. 4. — Rev. John Haynes Holmes, New York City.
Dec. 11. — Rev. Henry K. Sherrill, Brookline.
Dec. 18. — Rev. William I. Chamberlain, New York City.

1922.
Jan. 8. — Bishop Edwin H. Hughes, Malden.
Jan. 15. — Dean Charles R. Brown, New Haven, Conn.
Jan. 22. — Mr. Owen R. Lovejoy, New York City.
Jan. 29. — P. Whitwell Wilson, M. P., New York City and London.
Feb. 5. — Rev. Newton M. Hall, Springfield.
Feb. 12. — Rev. Neil McPherson, Springfield.
Feb. 19. — Mr. Alfred E. Stearns, Andover.
Feb. 26. — Rev. Daniel A. Evans, Cambridge.
March 5. — Rev. Henry S. MacCready, Willimantic, Conn.
March 12. — Dr. Albert Parker Fitch, Amherst.
March 19. — Rev. Fred W. Adams, Springfield.
April 9. — Dr. Howard A. Bridgman, Groton.
April 16. — Mr. Albert E. Roberts, New York City.
April 23. — Rev. William S. Beard, New York City.
April 30. — Rev. James G. Gilkey, Springfield.
Oct. 1. — Dean Edward M. Lewis, M. A. C.
Nov. 5. — Dr. Hugh Black, New York City.
Nov. 12. — Dr. Herbert J. White, Hartford, Conn.
Nov. 19. — Dr. Albert Parker Fitch, Amherst.
Nov. 26. — Dean Thomas Arkle Clark, Urbana, Ill.

TABLE IV. — *Attendance.*

A. *In work of College Grade.*

	Registration Nov. 30, 1921.			Registration Nov. 1, 1922.		
	Men.	Women.	Total.	Men.	Women.	Total.
Graduate students	53	8	61	48	6	54
Senior class	91	5	96	84	7	91
Junior class	93	8	101	89	6	95
Sophomore class	104	9	113	91	6	97
Freshman class	147	15	162	167	20	187
Special students	10	3	13	9	4	13
Totals	498	48	546	488	49	537

TABLE IV. — *Attendance* — Concluded.

B. Short Course Enrollment.

	Registration Nov. 30, 1921.			Registration Nov. 1, 1922.		
	Men.	Women.	Total.	Men.	Women.	Total.
Two-Year Course, second year	129	9	138	116	5	121
Two-Year Course, first year	150	5	155	128	8	136
Vocational Poultry Course	26	–	26	8	1	9
Unit Course	29	–	29	–	–	–
Totals	334	14	348	252	14	266

C. Other Short Course Enrollment.

School for Country Clergymen	18	1	19	31	2	33
Winter School	69	14	83	77	20	97
Summer School	67	192	259	23	147	170
Summer School for Federal men	65	–	65	–	–	–
School of Rural Home Life	–	–	–	–	16	16
Totals	219	207	426	131	185	316

D. Convention Registration.

	1921.	1922.
State institutional superintendents and farmers	50	–
Polish farmers' day	100	125
Farmers' week and annual poultry convention	3,000	2,000
Junior boys' and girls' prize winners' camp	95	100
Girls' camp (paid)	14	–
Boys' camp (paid)	34	–
One-day campers (boys and girls)	198	70
Extension workers' conference	80	80
Sheep breeders' conference	212	100
Clothing efficiency conference (2) for paid leaders	14	–
Clothing efficiency conference for local leaders	53	–
Tri-State Conference on Marketing	–	150
	3,850	2,625

TABLE V. — *Legislative Budget, 1922.*

Items.	Amount asked.	Amount granted.
Chemistry laboratory and equipment	$350,000 00	$150,000 00[1]
Improvements at power plant	80,000 00	63,000 00
Laboratory for horticultural manufactures	50,000 00	–
Improvements at Tillson Farm	5,000 00	5,000 00
Macadam road	8,000 00	–
Purchase of Brooks Farm	20,000 00	15,000 00
	$513,000 00	$233,000 00

[1] An additional appropriation of $150,000 to be made in 1923.

TABLE VI. — *Current Account, State Funds.*

	Requested 1922.	Appropriated 1922.	Deficiency Appropriation.[1]	Expended 1922.	Balance.
Personal services: —					
Administration	$43,360	$42,020	–	$41,180 88	$839 12
Instruction	203,175	187,875	–	184,440 92	3,434 08
General maintenance	120,000	118,000	$367 43	115,364 35	3,003 08
Experiment Station	66,075	60,000	36 00	59,014 57	1,021 43
Extension Service	59,780	52,290	2 70	50,693 81	1,598 89
Market Garden Field Station	6,500	6,000	–	5,453 54	546 46
Short Courses	53,640	48,000	–	47,418 28	581 72
Travel, office and other expenses	46,000	45,000	622 11	42,544 50	3,077 61
Teaching, laboratory supplies and equipment	56,000	55,000	361 05	55,800 59	—439 54
Experiment Station: —					
Supplies, equipment and publications	20,050	14,000	263 56	13,619 19	644 37
Travel and office expenses	4,785	3,300	5 16	4,081 81	—776 65
Extension Service, supplies, equipment, travel, etc.	44,000	35,000	910 62	37,702 69	—1,792 07
Short courses	19,235	12,000	78 94	11,793 16	285 78
Heat, light and power	68,000	59,000	3,375 00	64,049 62	—1,674 62
Farm	24,000	22,000	408 45	18,447 76	3,960 69
Repairs, ordinary	25,000	25,000	81 69	30,847 83	—5,766 14
Replacements	75,000	25,000	–	25,533 92	—533 92
Market Garden Field Station	3,825	3,000	230 36	3,624 85	—394 49
Fertilizer law control	14,500	13,000	–	12,961 80	38 20
Poultry disease law	6,500	6,000	17 91	6,135 61	—117 70
Milk-testing inspection law	700	600	9 60	631 30	—21 70
Commercial feedstuffs	8,000	7,000	4 79	7,011 19	—6 40
Trustees' expenses	1,200	1,200	–	874 07	325 93
Printing reports	5,000	2,000	–	1,965 82	34 18
	$974,325	$842,285	$6,775 37	$841,192 06	$7,868 31

[1] Balance from deficiency appropriation $680,000.

TABLE VII. — *Statistics of Freshmen entering Massachusetts Agricultural College September 1922.*

A. *Home Addresses of Students (classified by Towns and Cities.)*

Abington	1	Hopedale	1	Reading	3
Adams	1	Hopkinton	1	Richmond	1
Amherst	8	Hubbardston	1	Salisbury	1
Andover	1	Ipswich	1	Shelburne	4
Arlington	2	JACKSONVILLE, Fla.	1	Shrewsbury	1
Ashburnham	2	Kars, Armenia	1	South Hadley	2
Athol	2	LAWRENCE	2	Spencer	1
Barnstable	2	Longmeadow	1	SPRINGFIELD	10
Bernardston	1	Ludlow	1	Stoneham	3
BEVERLY	2	Manchester	2	Stoughton	1
Billerica	1	MANCHESTER, N. H.	1	Stow	2
Bolton	2	MELROSE	3	Sunderland	1
BOSTON	10	Methuen	1	TAUNTON	2
Bridgewater	1	Middleborough	1	Templeton	1
Brimfield	5	Milford	1	Tisbury	1
BROCKTON	3	Millis	1	Topsfield	1
Brookline	1	Millville	1	Townsend	1
CAMBRIDGE	2	Montpelier, Ohio	1	Vastarvik, Sweden	1
CHELSEA	1	Natick	3	Wallingford, Conn.	1
Colrain	2	Needham	1	WALTHAM	1
Conway	1	NEW BEDFORD	1	Ware	3
Dalton	2	NEW ROCHELLE, N. Y.	1	Warren	1
Deerfield	2	NEWTON	5	Westborough	1
East Bridgewater	1	NEW YORK, N. Y.	2	West Bridgewater	1
Easthampton	2	NORTHAMPTON	1	WESTFIELD	3
EVERETT	2	North Brookfield	1	WEST HARTFORD, Conn.	1
Fairhaven	1	Northfield	2	Westport, Conn.	1
FALL RIVER	1	Norwood	1	West Newbury	1
Glastonbury, Conn.	1	Orange	1	West Springfield	1
Grafton, Vt.	2	Oxford	1	Williamsburg	1
Greenfield	2	Pelham	1	Winchester	2
HABANA, Cuba	1	PORTLAND, Me.	1	WORCESTER	5
HOLYOKE	13	PROVIDENCE, R. I.	2		

TABLE VII. — *Statistics of Freshman entering Massachusetts Agricultural College, September 1922* — Continued.

B. Home Addresses (classified by States and Countries).

	Number.	Per Cent.		Number.	Per Cent.
Armenia	1	.53	New York	3	1.60
Connecticut	4	2.13	Ohio	1	.53
Cuba	1	.53	Rhode Island	2	1.06
Florida	1	.53	Sweden	1	.53
Maine	1	.53	Vermont	2	1.06
Massachusetts	169	90.37			
New Hampshire	1	.53		187	100.00

C. Home Addresses (classified by Counties of Massachusetts).

	Number.	Per Cent.		Number.	Per Cent.
Barnstable	2	1.18	Middlesex	31	18.34
Berkshire	4	2.36	Norfolk	5	2.96
Bristol	5	2.96	Plymouth	8	4.73
Dukes	1	.59	Suffolk	11	6.50
Essex	12	7.10	Worcester	22	13.01
Franklin	16	9.52			
Hampden	34	20.11		169	100.00
Hampshire	18	10.65			

D. Navitity of Parents.

	Number.	Per Cent.
Neither parent foreign born	134	71.65
Both parents foreign born	33	17.64
Father (only) foreign born	11	5.88
Mother (only) foreign born	6	3.20
No statistics	3	1.60
	187	100.00

E. Education of Father.

	Number.	Per Cent.
Common school	77	41.17
High school	51	27.27
Business school	15	8.02
College or university	32	17.11
No statistics	12	6.41
	187	100.00

TABLE VII. — *Statistics of Freshman entering Massachusetts Agricultural College, September 1922* — Concluded.

F. Religious Census.

	Membership.		Preference.		Totals.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist	22	11.76	2	1.06	24	12.97
Catholic	28	14.97	–	–	28	14.97
Congregationalist	52	27.80	18	9.62	70	37.43
Episcopal	9	4.81	1	.53	10	5.34
Methodist	16	8.55	–	–	16	8.55
Presbyterian	4	2.13	2	1.06	6	3.20
Unitarian	9	4.81	5	2.67	14	7.41
Universalist	1	.53	–	–	1	.53
Miscellaneous	12	6.41	5	2.67	17	9.09
No statistics	1	.53	–	–	1	.53
	154	82.30	33	17.61	187	100.00

G. Occupation of Father.

	Number.	Per Cent.
Agriculture and horticulture	41	21.92
Artisans	37	19.79
Business	43	22.99
Deceased or no statistics	21	11.23
Miscellaneous	24	12.83
Professional	21	11.23
	187	100.00

H. Intended Vocation of Student.

	Number.	Per Cent.
Agriculture or horticulture (practical)	75	40.11
Agriculture or horticulture (professional)	42	22.46
Professions	17	9.09
Miscellaneous	26	13.90
Undecided or no statistics	27	14.44
	187	100.00

I. Farm Experience.

	Number.	Per Cent.
Brought up on a farm	55	29.41
Not brought up on a farm and having no or practically no farm experience	45	24.06
Not brought up on a farm, but having had some farm experience	86	46.00
No statistics	1	.52
	187	100.00

J. Miscellaneous Statistics.

Average age . . . . . 19.19 years.

REPORT OF THE TREASURER.

For the Fiscal Year ending Nov. 30, 1922.

Balance Sheet.

		Dr.	Cr.
1921			
Dec. 1.	To balance on hand	$30,227 89	
1922			
Nov. 30.	To departmental income	136,039 79	
Nov. 30.	To receipts from State Treasurer	874,475 48	
Nov. 30.	To refunds to State Treasurer	216 45	
Nov. 30.	To receipts from United States Treasurer	119,802 58	
Nov. 30.	To November schedule in transit	109,305 12	
Nov. 30.	Refunds transferred to State Treasurer		$216 45
Nov. 30.	Expenditures for fiscal year		1,096,431 67
Nov. 30.	Income transferred to State Treasurer		136,039 79
Nov. 30.	Balance on hand		37,379 40
		$1,270,067 31	$1,270,067 31

Statement of Legislative Apportionment and Expenditures for Fiscal Year ending November 30, 1922, and Apportionment requested for 1923.

	Apportionment for Last Fiscal Year.		Expenditures.		Requested Apportionment for New Fiscal Year.	
College:						
Personal services	$348,262 43		$340,986 15		$359,030 00	
Maintenance	210,848 30	$559,110 73	211,690 30	$552,676 45	220,695 00	$579,725 00
Experiment Station:						
Personal services	$60,036 00		$59,014 57		$72,420 00	
Maintenance	17,568 72	77,604 72	17,701 00	76,715 57	20,000 00	92,420 00
Extension Service:						
Personal services	$52,292 70		$50,693 81		$52,180 00	
Maintenance	35,910 62	88,203 32	37,702 69	88,396 50	40,000 00	92,180 00
Short Courses:						
Personal services	$48,000 00		$47,418 28		$53,230 00	
Maintenance	12,078 94	60,078 94	11,793 16	59,211 44	12,000 00	65,230 00
Market Garden Field Station:						
Personal services	$6,000 00		$5,453 54		$6,000 00	
Maintenance	3,230 36	9,230 36	3,624 85	9,078 39	4,000 00	10,000 00
Trustees travel	$1,200 00		$874 07		$1,200 00	
Printing reports	2,000 00		1,965 82		2,000 00	
Commercial feedstuffs	7,004 79		7,011 19		9,000 00	
Totals		10,204 79		9,851 08		12,200 00
Fertilizer law	$13,000 00		$12,961 80		$14,500 00	
Poultry law	6,017 91		6,135 61		7,000 00	
Milk testing law	609 60		631 30		600 00	
Totals		19,627 51		19,728 71		22,100 00
Replacements	$25,000 00	25,000 00	$25,533 92	25,533 92	$40,000 00	40,000 00
Totals	–	$849,060 37	–	$841,192 06	–	$913,855 00
Balance unexpended	–	–	–	7,868 31	–	–
	–	–	–	$849,060 37	–	–

CASH STATEMENT.

	Other Funds.	State Funds.	Totals.
Balance Dec. 1, 1921	$30,227 89	–	$30,227 89
Receipts.			
College receipts from students and others			21,864 17
Tuition	–	$3,998 01	
Laboratory fees	–	5,863 81	
Rents	–	12,002 35	
Departmental sales			73,859 16
Produce	–	63,971 48	
Miscellaneous	–	9,887 68	
Experiment Station			8,723 76
Cranberry receipts	–	6,138 21	
Chemical receipts	–	466 74	
Miscellaneous	–	2,118 81	
Extension Service			1,086 90
Correspondence Courses	–	860 12	
Miscellaneous	–	226 78	
Short Courses			6,893 91
Students' fees	–	6,385 08	
Winter school	–	450 00	
Miscellaneous	–	58 83	
Market Garden Field Station			3,594 41
Produce	–	3,594 41	
Feed Law	–	267 00	267 00
Fertilizer Law	–	16,571 08	16,571 08
Milk testing law	–	675 05	675 05
Poultry disease law	–	2,504 35	2,504 35
Treasurer of the Commonwealth			874,475 48
Maintenance	–	746,847 17	
Special appropriations	–	122,852 49	
Endowment	3,313 32	–	
Department of Education	1,462 50	–	
Federal Government			119,802 58
Land Grant of 1862	7,300 00	–	
Hatch fund of 1887	15,000 00	–	
Morrill fund of 1890	16,666 67	–	
Adams fund of 1906	15,000 00	–	
Nelson fund of 1907	16,666 66	–	
Smith Lever fund of 1914	30,644 89	–	
Short Course, two years	18,524 36	–	
November schedules in transit	–	109,305 12	109,305 12
	$154,806 29	$1,115,044 57	$1,269,850 86
Payments.			
College expenses			$598,085 60
Personal services	$45,409 15	$340,986 15	
Maintenance	–	211,690 30	
Experiment Station			105,834 07
Personal services	28,698 50	59,014 57	
Maintenance	420 00	17,701 00	
Extension Service			115,744 32
Personal services	26,306 30	50,693 81	
Maintenance	1,041 52	37,702 69	
Short Courses			74,762 86
Personal services	13,046 85	47,418 28	
Maintenance	2,504 57	11,793 16	
Market Garden Field Station			9,078 39
Personal services	–	5,453 54	
Maintenance	–	3,624 85	
Trustees travels	–	874 07	874 07
Printing reports	–	1,965 82	1,965 82
Replacements	–	25,533 92	25,533 92
Commercial feed-stuffs	–	7,011 19	7,011 19
Fertilizer law	–	12,961 80	12,961 80
Milk testing law	–	631 30	631 30
Poultry disease law	–	6,135 61	6,135 61
Special appropriations			137,812 72
1921 Market Garden Field Station Administration Building	–	2,668 99	
1922 Purchase of Brooks Farm	–	15,000 00	
1922 Chemistry Building	–	56,720 37	
1922 Improvements to Power Plant	–	58,604 71	
1922 Improvements to Tillson Farm	–	4,818 65	
Income	–	136,039 79	136,039 79
Balance	37,379 40	–	37,379 40
	$154,806 29	$1,115,044 57	$1,269,850 86

Current Accounts, 1922.

Disbursements and Receipts.

Accounts.	Disbursements from Nov. 30, 1921, to Nov. 30, 1922.	Receipts from Nov. 30, 1921, to Nov. 30, 1922.	Apportionment for Year ending Nov. 30, 1922.	Balance to Credit.
Administration:				
Dean's office	$569 26	–	$703 00	$133 74
Executive order	8,241 69	–	12,920 57	4,678 88
President's office	1,843 06	$0 25	2,200 69	357 63
Registrar's office	771 70	15 00	807 40	35 70
Salaries	41,180 88	–	42,020 00	839 12
Treasurer's office	1,615 41	97 94	1,812 76	197 35
Maintenance, academic:				
Agricultural economics	564 60	–	568 75	4 15
Agricultural education	224 38	–	400 65	176 27
Agronomy	1,248 92	342 50	1,203 26	—45 66
Animal husbandry	648 51	140 00	600 95	—47 56
Beekeeping	353 69	34 32	521 60	167 91
Botany	1,497 32	598 50	1,533 50	36 18
Chemistry	8,205 18	2,267 63	5,255 23	—2,949 95
Dairying	30,463 16	23,248 66	33,027 30	2,564 14
Domestic Science	1,281 74	79 70	1,410 66	128 92
Economics and sociology	223 07	–	223 28	21
Entomology	1,097 39	114 50	1,250 00	152 61
Farm management	374 90	34 50	511 92	137 02
Floriculture	7,463 73	2,991 69	7,502 55	38 82
Forestry	273 50	6 00	350 20	76 70
General agriculture	2,451 39	–	2,500 00	48 61
Horticultural manufactures	3,015 35	602 75	3,582 05	566 70
Hospital	3,833 91	777 25	3,340 56	—493 35
Landscape gardening	587 25	401 50	529 34	—57 91
Language and literature	243 71	153 00	300 00	56 29
Mathematics	405 03	61 70	490 00	84 97
Microbiology	2,285 89	441 68	2,154 21	—131 68
Military science	1,459 21	30 00	1,420 60	—38 61
Mount Toby	3,358 91	2,273 06	3,508 85	149 94
Physical education	1,028 23	–	1,006 71	—21 52
Physics	788 62	69 00	718 85	—69 77
Pomology	5,161 43	2,979 10	5,321 59	160 16
Poultry husbandry	14,304 92	14,559 37	14,506 73	201 81
Rural engineering	902 28	182 35	900 00	—2 28
Rural sociology	160 71	–	200 00	39 29
Vegetable gardening	6,114 50	2,558 15	6,501 70	387 20
Veterinary science	2,139 23	108 00	2,007 00	—132 23
Women's dormitory	3,117 36	6,509 46	2,702 64	—414 72
Zoölogy and geology	554 12	418 00	650 00	95 88
Maintenance, general:				
Farm	38,363 24	15,597 67	37,559 05	—804 19
General horticulture	8,865 58	330 58	8,529 46	—336 12
Graduate school	54 94	–	100 00	45 06
Grounds	8,693 62	10 10	8,900 00	206 38
Library	8,713 44	67 12	8,281 24	—432 20
General expense	3,114 49	3,161 21	–	–
Operating and maintenance	140,448 88	14,461 09	140,544 64	95 76
Replacements	25,533 92	–	25,000 00	—533 92
Endowment fund	10,613 32	10,613 32	10,613 32	3,650 00
Instruction:				
Salaries	184,440 92	–	187,875 00	3,434 08
United States Treasurer, Morrill Fund	16,666 67	16,666 67	16,666 67	9,722 22
United States Treasurer, Nelson Fund	16,666 66	16,666 66	16,666 66	9,722 21
State Treasurer, account of schedules	–	578,210 37	–	–
Income to State Treasurer	95,723 33	–	–	–
	$717,953 15	$717,880 35	$627,901 14	$31,880 24
Less refunds	72 80	–	–	–
	$717,880 35	$717,880 35	–	–
Balance beginning fiscal year Dec. 1, 1921	–	23,094 43	–	–
Balance on hand Nov. 30, 1922	23,094 43	–	–	–
	$740,974 78	$740,974 78	–	–

College Accounts.

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1921	–	$23,094 43
Institution receipts Nov. 30, 1922	–	95,723 33
State Treasurer's receipts Nov. 30, 1922	–	578,210 37
United States Treasurer's receipts Nov. 30, 1922	–	33,333 33
State Treasurer, Department of Education	–	1,462 50
Endowment Fund	–	10,613 32
Total Disbursements	$598,085 60	–
Receipts turned in to State Treasurer	95,723 33	–
	$693,808 93	$742,437 28
Bills receivable Dec. 1, 1921 deducted	–	8,552 48
Bills payable Dec. 1, 1921 deducted	3,801 17	–
	$690,007 76	$733,884 80
Bills receivable Nov. 30, 1922	–	14,219 25
Bills payable Nov. 30, 1922	1,063 12	–
Balance	57,033 17	–
	$748,104 05	$748,104 05

Farm Disbursements.

	Repairs.	Labor.	Equipment.	Feed.	Supplies.	Sundry.	Bedding.	Fertilizer.	Seeds.	Improvements.	Totals.
Dairy cattle	-	$4,100 07	$129 24	$412 97	$1,108 51	$954 59	-	-	-	-	$6,705 38
Horses	-	1,337 93	54 05	-	16 17	217 28	-	-	-	-	1,625 43
Sheep	-	1,088 39	29 09	-	17 88	59 77	-	-	-	-	1,195 13
Live stock	-	434 12	-	6,799 35	-	-	$3,253 35	-	-	-	10,486 82
Swine	-	1,061 17	9 36	674 16	7 37	81 67	-	-	-	-	1,833 73
Teams	-	379 61	191 43	-	-	189 37	-	-	-	-	760 41
Field crops	-	4,364 30	-	-	1 50	27 16	-	$975 93	$444 70	-	5,813 59
Tools and machinery	$752 29	666 28	320 08	-	787 58	-	-	-	-	-	2,526 23
Miscellaneous	-	6,483 61	-	-	89 04	136 57	-	-	-	$707 30	7,416 52
Totals	$752 29	$19,915 48	$733 25	$7,886 48	$2,028 05	$1,666 41	$3,253 35	$975 93	$444 70	$707 30	$38,363 24

Farm Credits.

	Wool.	Milk.	Stock.	Sundry.	Labor.	Field Crops.	Tools and Machinery.	Totals.
Dairy cattle	-	$7,614 30	$4,452 36	-	-	-	-	$12,066 66
Horses	-	-	40 00	-	-	-	-	40 00
Sheep	$154 46	-	632 31	$160 00	-	-	-	946 77
Live stock, supplies	-	-	-	117 18	-	-	-	117 18
Field crops	-	-	-	-	-	$586 71	-	586 71
Swine	-	-	828 10	-	-	-	-	828 10
Teams	-	-	-	-	$47 44	-	-	47 44
Tools and machinery	-	-	-	-	-	-	$17 00	17 00
Miscellaneous	-	-	-	851 64	96 17	-	-	947 81
Totals	$154 46	$7,614 30	$5,952 77	$1,128 82	$143 61	$586 71	$17 00	$15,597 67

Agricultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Agronomy	$1,248 92	$342 50
Animal husbandry	648 51	140 00
Dairying	30,463 16	23,248 66
Farm	38,363 24	15,597 67
Farm management	374 90	34 50
Poultry husbandry	14,304 92	14,559 37
Rural engineering	902 28	182 35
Division totals	$86,305 93	$54,105 05

Summary.

	Dr.	Cr.
By total division receipts		$54,105 05
By bills receivable		13,065 67
By net apportionment		34,204 16
To total division disbursements	$86,305 93	
To bills payable	307 28	
Balance	14,761 67	
	$101,374 88	$101,374 88

Inventory of Quick Assets.

	Nov. 30, 1921.	Nov. 30, 1922.
Inventory of produce	$10,487 81	$13,038 91
Inventory of cattle	18,975 00	19,510 00
Inventory of swine	701 00	1,487 00
Inventory of horses	3,850 00	3,800 00
Inventory of poultry	3,390 00	4,243 75
Inventory of sheep	1,842 00	1,805 00
	$39,245 81	$43,884 66

Horticultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Floriculture	$7,463 73	$2,991 69
Forestry	273 50	6 00
General horticulture	8,865 58	330 58
Grounds	8,693 62	10 10
Horticultural manufactures	3,015 35	602 75
Landscape gardening	587 25	401 50
Mount Toby	3,358 91	2,273 06
Pomology	5,161 43	2,979 10
Vegetable gardening	6,114 50	2,558 15
Division totals	$43,533 87	$12,152 93

Horticultural Division — *Concluded.*

Summary.

	Dr.	Cr.
3y total division receipts		$12,152 93
3y bills receivable		830 64
3y net apportionment		32,572 81
Co total division disbursements	$43,533 87	
Co bills payable	25 69	
3y balance	1,996 82	
	$45,566 38	$45,556 38

Inventory of Quick Assets.

	Nov. 30, 1921.	Nov. 30, 1922.
'loriculture	$2,000 00	$1,000 00
3eneral horticulture (live stock)	1,285 00	1,385 00
Iorticultural manufactures	150 00	420 00
Iount Toby	660 00	98 75
'omology	1,400 00	1,300 00
'egetable gardening	245 00	75 00
	$5,740 00	$4,278 75

Experiment Station.

Disbursements and Receipts.

	Disbursements from Dec. 1, 1921, to Nov. 30, 1922.	Receipts from Dec. 1, 1921, to Nov. 30, 1922.	Apportionment for Year ending Nov. 30, 1922.	Balance to Credit.
ıdministration	$1,413 42	$12 00	$1,568 38	$154 96
ıgricultural	9,763 79	547 09	9,468 13	—295 66
ıgricultural economics	675 46	–	675 00	— 46
3otanical	2,557 89	–	2,546 36	—11 53
'hemical	3,005 14	466 74	3,432 83	427 69
'ranberry	4,298 39	6,138 21	4,004 46	—293 93
Intomological	685 35	–	700 00	14 65
'reight and express	536 96	–	300 00	—236 96
ibrary	1,029 98	–	1,040 82	10 84
Ieteorology	595 04	–	600 00	4 96
Iicrobiology	991 53	–	1,000 00	8 47
'omology	2,703 94	1,559 72	3,100 00	396 06
'oultry	3,844 03	–	3,200 00	—644 03
'ublications	2,143 70	–	3,136 24	992 54
alaries	70,453 16	–	71,632 50	1,179 34
'reasurer's office	408 69	–	400 00	—8 69
'eterinary	737 80	–	800 00	62 20
Iatch fund	–	15,000 00	–	–
ıdams fund	–	15,000 00	–	–
tate Treasurer, account of schedules	–	76,715 57.	–	–
ncome remitted to State Treasurer	8,723 76	–	–	–
	$114,568 03	$115,439 33	$107,604 72	$1,760 45
ess refunds	10 20	–	–	–
	$114,557 83	$115,439 33	–	–
3alance beginning fiscal year Dec. 1, 1921	–	3,112 50	–	–
3alance on hand Nov. 30, 1922	3,994 00	–	–	–
	$118,551 83	$118,551 83	–	–

Experiment Station — *Concluded.*

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1921	–	$3,112 50
Receipts from State Treasurer	–	76,715 57
Receipts from United States Treasurer	–	30,000 00
Receipts from other sources	–	8,723 76
Total disbursements	$105,834 07	–
Receipts turned in to State Treasurer	8,723 76	–
	$114,557 83	$118,551 83
Bills receivable Dec. 1, 1921 deducted	–	1,340 16
Bills payable Dec. 1, 1921 deducted	173 73	–
	$114,384 10	$117,211 67
Bills receivable Nov. 30, 1922	–	1,046 60
Bills payable Nov. 30, 1922	34 43	–
Balance	3,839 74	–
	$118,258 27	$118,258 27

Extension Service.

Disbursements and Receipts.

Classification.	Disbursements.	Receipts.	Apportionment.	Balance.
Administration	$3,271 64	$106 96	$4,036 18	$764 54
Animal husbandry	1,055 70	–	1,200 00	144 30
Co-operative marketing	944 25	–	1,050 39	106 14
Correspondence courses	1,654 33	860 12	1,512 69	—141 64
County agents' work	1,335 22	–	1,200 50	—134 72
Clothing efficiency	1,428 02	–	839 76	—588 26
Dairying	81 47	2 65	450 00	368 53
Entomology	22 80	–	25 00	2 20
Exhibits	706 13	–	750 00	43 87
Extension courses at college	1,489 34	–	1,200 00	—289 34
Extension schools	125 39	–	268 67	143 28
Farm management demonstration	1,245 19	49 70	1,604 70	359 51
Forestry	45 20	–	–	—45 20
Home demonstration agents	2,224 10	67 47	2,027 59	—196 51
Home gardening	541 01	–	550 75	9 74
Horticultural manufactures	1,683 76	–	1,200 00	—483 76
Junior extension work	6,340 44	–	5,694 43	—646 01
Landscape extension	566 22	–	1,200 00	633 78
Lectures	53 59	–	50 00	—3 59
Library extension	167 20	–	300 00	132 80
Nutrition and household management	2,099 30	–	790 23	—1,309 07
Plant diseases	–	–	25 00	25 00
Pomology	1,769 70	–	1,501 23	—268 47
Poultry husbandry	1,235 81	–	1,200 00	—35 81
Printing	6,766 54	–	5,730 44	—1,036 10
Personal services	50,693 81	–	52,290 00	1,596 19
Rural engineering	196 92	–	500 00	303 08
Soils and crops	653 42	–	1,005 76	352 34
State Treasurer, account of schedules	–	88,396 50	–	–
Income to State Treasurer	1,086 90	–	–	–
	$89,483 40	$89,483 40	$88,203 32	—$193 18

EXTENSION SERVICE — *Concluded.*

Summary.

	Disbursements.	Receipts.
alance Dec. 1, 1921[1]	–	$4,006 75
eceipts Nov. 30, 1922	–	1,086 90
eceived from State Treasurer	–	88,396 50
eceived from United States Treasurer	–	30,644 89
isbursements to Nov. 30, 1922	$115,744 32	–
eceipts turned in to State Treasurer	1,086 90	–
	$116,831 22	$124,135 04
ills receivable Dec. 1, 1921 deducted	–	14 51
ills payable Dec. 1, 1921 deducted	753 88	–
	$116,077 34	$124,120 53
ills receivable Nov. 30, 1922	–	55 47
ills payable Nov. 30, 1922	–	–
alance	8,098 66	–
	$124,176 00	$124,176 00

[1] Includes Federal Smith-Lever Fund.

SMITH–LEVER FUND (FEDERAL).

	Disbursements.	Receipts.
dministration	$112 64	–
nimal husbandry	70	–
istrict and county agents	5 60	–
o-operative marketing	95	–
arm management demonstration	2 45	–
ome economics	16 76	–
ome gardening	1 20	–
unior Extension work	26 80	–
omology	42 60	–
oultry husbandry	3 84	–
rinting and publications	742 50	–
alaries	26,306 30	–
lothing efficiencies	81 63	–
utrition and household management	3 85	–
tate Treasurer	–	$30,644 89
	$27,347 82	$30,644 89
alance beginning fiscal year December 1, 1921	–	4,006 75
alance on hand November 30, 1922	7,303 82	–
Totals	$34,651 64	$34,651 64

SHORT COURSES.

	Disbursements.	Receipts.	Apportionment.	Balance.
gricultural economics	$15 00	–	$100 00	$85 00
gronomy	591 22	$446 00	500 00	—91 22
nimal husbandry	103 94	290 00	121 01	17 07
otany	–	6 50	–	–
airying	3,000 00	465 45	3,000 00	–
omestic science	87 99	–	100 00	12 01
ntomology	41 75	–	50 00	8 25
arm management	54 00	–	50 00	—4 00
loriculture	99 09	68 00	100 00	91
orestry	117 42	–	100 00	—17 42

Short Courses — *Concluded.*

	Disbursements.	Receipts.	Apportionment.	Balance.
General horticulture	$170 38	$114 50	$200 00	$29 6
Horticultural manufactures	682 11	–	750 00	67 8
Library	88 58	–	150 00	61 4
Mathematics	–	4 00	–	–
Microbiology	50 00	75 00	50 00	–
Personal services	47,548 28	–	48,000 00	451 7
Pomology	1,087 33	–	1,004 50	—82 8
Poultry husbandry	599 23	980 00	600 00	7
Rural engineering	846 88	326 50	850 00	3 1
Short course office	3,652 17	58 83	3,814 73	162 5
Treasurer's office	201 25	–	200 00	—1 2
Tuition	–	3,459 13	–	–
Vegetable gardening	304 82	150 00	338 70	33 8
Winter school registration	–	450 00	–	–
	$59,341 44	$6,893 91	$60,078 94	$737 5
Less refunds	130 00	–	–	–
	$59,211 44	–	–	–

Summary.

	Dr.	Cr.
State appropriation		$60,078 94
Amount of receipts		6,893 91
Amount of receipts transferred to State Treasurer	$6,893 91	
Department expenditures	59,211 44	
Balance unexpended	867 50	
Totals	$66,972 85	$66,972 85

Market-Gardening Field Station.

	Dr.	Cr.
Labor	$5,453 54	
Maintenance	3,628 30	
Totals	$9,081 84	
Less refund	3 45	
	$9,078 39	
State appropriation		$9,230 36
Amount of receipts		3,594 41
Amount of receipts transferred to State Treasurer	$3,594 41	
Department expenditures	9,078 39	
Balance unexpended	151 97	
Totals	$12,824 77	$12,824 77

Special Appropriations.

	Date made.	Appropriation.	Amount expended to Date.	Unexpended Balance.
arket-Garden Field Station administration building	1921	$10,000 00	$10,000 00	–
hemistry building	1922	150,000 00	56,720 37	$93,279 63
ower plant improvements	1922	63,000 00	58,604 71	4,395 29
urchase of Brooks Farm	1922	15,000 00	15,000 00	–
illson Farm improvements	1922	5,000 00	4,818 65	181 35
		$243,000 00	$145,143 73	$97,856 27
mount spent previous to Dec. 1, 1921	–	–	–	7,331 01
mount expended during fiscal year	–	–	–	137,812 72
nexpended balance Nov. 30, 1922	–	–	97,856 27	- –
		$243,000 00	$243,000 00	$243,000 00

Inventory — Real Estate.

Land (Estimated Value).

ngus land	$800 00
llen place	500 00
aker place	2,500 00
angs place	2,350 00
rooks farm	11,000 00
rown land	500 00
harmbury place	450 00
ark place	4,500 00
ollege farm	37,000 00
ranberry land	12,745 00
eorge Cutler, Jr., trustee	2,700 00
ickinson land	7,850 00
arlow farm and orchard	3,284 63
awley and Brown place	675 00
ellogg place	3,368 45
oomis place	415 00
ouisa Baker place	5,000 00
arket-Garden Field Station	4,800 00
ount Toby demonstration forest	30,000 00
ewell farm	2,800 00
d creamery place	1,000 00
ven farm	5,000 00
lham quarry	500 00
lson farm	2,950 00
estcott place	2,250 00
	$144,938 08

Inventory — *Continued.*

College Buildings (Estimated Value) 1922.

	Inventory at Beginning of Year.	Per Cent deducted.	Value at Beginning of Year less Deterioration.	Repairs and Improvements during Year.	Total Value at Close of Fiscal Year.
ms Hall	$129,616 70	2	$127,024 37	$580 14	$127,604 51
ary	2,905 76	2	2,847 64	37 18	2,884 82
hier's House	1,510 80	5	1,435 26	240 73	1,675 99
rk Hall	61,376 07	2	60,148 55	918 04	61,066 59
d storage laboratory	10,586 37	2	10,374 64	75	10,375 39
ry barn and storage	30,958 65	3	30,028 89	134 09	30,162 98
per Hall	69,052 27	3	66,980 70	2,634 40	69,615 10
ll Hall and gun shed	9,245 82	5	8,783 53	399 50	9,183 03
rfee glass house, old	7,479 76	5	7,105 77	192 82	7,298 59
rfee glass house, new	11,015 26	5	10,464 50	–	10,464 50
m blacksmith shop	444 39	3	431 06	–	431 06

INVENTORY — *Continued.*

College Buildings (Estimated Value) 1922 — Concluded.

	Inventory at Beginning of Year.	Per Cent de-ducted.	Value at Beginning of Year less Deterioration.	Repairs and Improvements during Year.	Total Value at Close of Fiscal Year.
Farm bull pens	–	–	–	–	$3,377 5
Farm bungalow	$2,563 57	3	$2,486 66	$22 71	2,509 3
Farmhouse No. 1	2,922 50	3	2,834 82	262 24	3,097 [illegible]
Farmhouse No. 2	4,366 22	8	4,016 92	31 85	4,048 7
Fernald Hall	71,845 57	2	70,408 66	372 40	70,781 [illegible]
Flint Laboratory	69,131 75	2	67,749 11	1,106 97	68,856 [illegible]
French Hall	45,824 27	2	44,907 78	569 17	45,476 [illegible]
Grinnell Arena	8,905 84	2	8,727 72	13 39	8,741 1
Grounds tool shed	210 05	5	199 55	–	199 [illegible]
Harlow house	2,008 97	5	1,908 52	48 04	1,956 [illegible]
Horse barn	4,755 83	3	4,613 16	42 64	4,655 [illegible]
Head of division of horticulture	2,187 92	5	2,078 52	408 08	2,486 [illegible]
Horticultural barn	3,707 60	3	3,596 37	59 06	3,655 [illegible]
Horticultural tool shed	1,615 97	3	1,567 39	–	1,567 [illegible]
Horticultural open shed	494 05	5	469 35	–	469 [illegible]
Horticultural manufactures shed	3,624 51	5	3,443 28	28	3,443 [illegible]
Hospital	14,617 40	2	14,325 05	1,152 94	15,477 [illegible]
Jewett house and barn	3,153 68	5	2,996 00	110 31	3,106 [illegible]
Machinery barn	3,407 21	3	3,304 99	26 70	3,331 [illegible]
Market-Garden Field Station barn	3,118 86	3	3,024 29	–	3,024 [illegible]
Market-Garden Field Station Foreman's cottage	4,234 05	3	4,107 03	–	4,107 [illegible]
Market-Garden Field Station Greenhouse plant	9,476 25	5	9,002 44	–	9,002 [illegible]
Market-Garden Field Station Wagon shed	522 70	3	507 02	–	507 [illegible]
Market-Garden Field Station Administration building	9,000 00	3	8,730 00	–	8,730 [illegible]
Market-Garden Field Station Boiler House	5,820 00	3	5,645 40	–	5,645 [illegible]
Mathematical building	4,670 07	5	4,436 57	101 80	4,538 [illegible]
Memorial Hall	105,000 00	2	102,900 00	586 14	103,486
Microbiology building	57,144 96	2	56,002 06	241 38	56,243
Military storage	214 34	5	203 62	–	203
Mount Toby house and barn	3,486 32	5	3,312 00	–	3,312
North dormitory	26,916 37	2	26,378 04	841 43	27,219
Physics laboratory	4,432 97	5	4,211 32	585 86	4,797
Piggery	2,469 43	3	2,395 35	–	2,395
Poultry departments —					
No. 1, demonstration building	1,481 31	2	1,451 68	64 35	1,516
2, oil house	75 06	2	73 56	–	73
3, brooder, killing and fattening laboratory	2,361 99	2	2,314 75	35	2,315
4, mechanics, storage building and incubator cellar	3,367 23	2	3,299 89	669 78	3,969
5, laying house	1,665 32	2	1,632 01	–	1,632
6, manure shed	89 16	2	87 38	–	87
7, small henhouse	44 87	2	43 97	–	43
8, breeding house	1,423 70	2	1,395 23	50 06	1,445
9, experimental breeding house	557 40	2	546 25	–	546
10, duck house	92 25	2	90 40	70	91
11, unit house for 200 hens	466 69	2	457 36	–	457
12, unit house for 100 hens	376 57	2	369 04	–	369
Power plant and storage building including coal pocket	48,055 29	2	47,094 18	1,177 66	48,271
President's house	12,994 52	3	12,604 68	422 54	13,027
Rural engineering building	15,316 55	2	15,010 22	284 22	15,294
Sheep barn	1,380 88	3	1,339 45	3 58	1,343
South dormitory	39,298 22	2	38,512 26	1,846 12	40,358
Stable for cavalry unit	18,141 38	3	17,597 14	552 17	18,149
Stockbridge Hall	166,475 88	2	163,146 36	1,284 45	164,430
Agronomy greenhouse	1,924 16	2	1,885 68	78 27	1,963
Stockbridge house	1,570 32	5	1,491 80	864 69	2,356
Stone chapel	30,079 72	2	29,478 13	289 20	29,767
Turbine house	18,436 15	2	18,067 43	–	18,067
Vegetable plant house	4,160 45	5	3,952 43	412 88	4,365
Veterinary laboratory and stable	21,343 68	2	20,916 81	1,305 10	22,221
Waiting station	457 33	2	448 18	59 09	507
Wilder Hall	33,171 15	2	32,507 73	577 91	33,085
Young stock barns	5,635 11	3	5,466 06	42 40	5,508
	$1,246,483 42	–	$1,217,393 96	$21,706 56	$1,242,47

INVENTORY — *Continued.*

College Equipment (Estimated Value).

dministrative division:	
Dean's Office	$1,147 15
President's Office	2,728 50
Registrar's Office	1,238 97
Treasurer's Office	4,707 02
gricultural division:	
Agronomy	8,444 94
Animal Husbandry	896 10
Dairy	25,838 54
Farm	20,905 57
Farm Livestock	26,602 00
Farm Management	984 39
General Agriculture	2,528 15
Poultry	10,752 27
Rural Engineering	6,999 62
omestic Science	3,495 18
ining Hall	26,183 81
xtension	12,968 93
eneral Science:	
Apiary	2,362 11
Botanical	24,038 35
Chemistry	10,454 42
Entomology	5,216 21
Mathematics	2,314 25
Microbiology	7,182 10
Physics	7,379 12
Veterinary	10,557 76
Zoölogy and Geology	17,346 34
raduate School	97 55
orticultural division:	
Floriculture	30,311 98
Forestry	2,567 46
General Horticulture	7,892 44
Grounds	2,086 52
Horticultural Manufactures	5,490 05
Landscape Gardening	5,522 31
Market-Garden Field Station	3,841 73
Mount Toby Reservation	176 00
Pomology	8,437 69
Vegetable Garden	3,706 07
ospital	989 40
umanities division:	
Economics and Sociology	202 70
Language and Literature	621 50
ibrary	126,958 35
ilitary	1,360 28
perating and Maintenance:	
College Supply	1,659 83
Fire Apparatus	1,700 00
General Maintenance:	
Office	854 05
Carpentry and Masonry Supplies	5,349 71
Carpentry and Masonry Tools	4,087 28
Electrical Supplies	3,735 47
Electrical Tools	178 55
Electrical Commencement supplies	619 75
Heating and Plumbing supplies	10,268 00
Heating and Plumbing Tools	2,635 34
Painting Supplies	1,342 90
Painting Tools	283 73
Steam Main	53,620 69
Lighting Lines	9,930 79
Janitor's Supplies	1,401 29
Sewer Line	13,942 54
Water Mains	13,374 41
Power Plant:	
General Equipment	113,492 80
Tools	255 04
Supplies	465 18
Fuel	13,125 00

INVENTORY — *Continued.*

College Equipment (Estimated Value) — Concluded.

Physical Education	$1,776
Rural Social Science:	
Agricultural Economics	1,599
Agricultural Education	1,466
Rural Sociology	376
Rural Social Science	40
Short Course	1,552
Textbooks	2,878
Trophy Room	1,200
Women's Dormitory	9,912
Memorial Hall	21,564
Total	$738,221

Experiment Station Buildings (Estimated Value).

	Inventory at Beginning of Year.	Per Cent.	Cost at Beginning of Year, less Per Cent Deterioration.	Repairs and Improvements during Year.	Total Value at Close of Year
Agricultural laboratory	$14,763 72	2	$14,468 45	$66 76	$14,535
Agricultural barn	4,202 20	3	4,076 13	–	4,076
Agricultural farmhouse	1,604 59	3	1,556 45	54 08	1,610
Agricultural glasshouse	349 17	5	331 71	–	331
Brooks house	–	–	–	–	2,500
Brooks barn and sheds	–	–	–	–	1,500
Cranberry buildings	3,080 19	5	2,926 18	–	2,926
Entomological glasshouses	648 21	5	615 80	–	615
Plant and animal chemistry laboratory	27,630 86	2	27,078 24	302 49	27,380
Plant and animal chemistry barns	4,581 64	3	4,444 19	659 25	5,103
Plant and animal chemistry dairy	1,615 97	3	1,567 49	–	1,567
Six poultry houses	615 68	2	603 37	113 78	717
Tillson house	527 88	5	501 49	448 58	950
Tillson barn	977 41	5	928 54	–	928
Tillson poultry houses (4)	–	–	–	–	2,749
Tillson incubator cellar	–	–	–	–	713
Totals	$60,597 52	–	$59,098 04	$1,644 94	$68,206

Experiment Station Equipment (Estimated Value).

Apiary	$152
Agricultural Economics Department	477
Agricultural Laboratory	7,339
Botanical laboratory	6,180
Chemical laboratory	25,685
Cranberry Station	3,841
Director's office	5,031
Entomological laboratory	24,063
Meteorological laboratory	778
Microbiological laboratory	2,771
Pomology	4,609
Poultry department	5,297
Treasurer's Office	1,021
Veterinary	594
Total	$87,843

INVENTORY — *Concluded.*

Summary.

and	$144,938 08
ollege buildings	1,242,478 02
ollege equipment	738,221 71
xperiment Station buildings	68,206 23
xperiment Station equipment	87,843 47
Total	$2,281,687 51

	Acres.
ollege estate (area)	702 19
ranberry Station, Wareham (area)	23 67
[arket Garden Field Station, Lexington (area)	12 00
[ount Toby demonstration forest (area)	755 27
ifle range	46 20
elham quarry	50
Total acreage	1,539 83

STUDENTS' TRUST FUND ACCOUNT.

	Disbursements, Year ending Nov. 30, 1922.	Receipts, Year ending Nov. 30, 1922.	Balance on Hand.	Balance brought forward Dec. 1, 1921.
:hletics	$17,035 79	$19,595 56	$295 06	$—2,264 71
ining Hall	88,070 72	89,050 92	43 27	—936 93
eys	107 00	112 00	86 00	81 00
udents' deposits	52,030 35	51,079 25	14,866 07	15,817 17
›cial Union	3,624 42	3,306 93	483 07	800 56
›xtbooks	11,981 69	10,904 95	1,080 22	2,156 96
:hletic Field	–	–	169 70	169 70
niforms	4,898 80	4,876 48	3,495 30	3,517 62
›w-Testing	22,734 40	23,438 14	2,220 34	1,516 60
Totals	$200,483 17	$202,364 23	$22,739 03	$20,857 97
ılance beginning fiscal year	–	20,857 97	–	–
ılance on hand Nov. 30, 1922	22,739 03	–	–	–
Totals	$223,222 20	$223,222 20	–	–

CONDENSED OPERATING STATEMENT OF THE DINING HALL.

	Operating Charges.	Income.
1921.		
ec. 1, Balance	—$936 93	–
1922.		
ov. 30, Total Disbursements	88,070 72	–
Outstanding Bills	5,225 15	–
Total Collections	–	$89,050 92
Accounts Outstanding	–	1,100 71
Inventory	–	10,482 31
Balance	6,401 14	–
Totals	$100,633 94	$100,633 94

Endowment Fund.[1]

	Principal.	Income.
United States grant (5 per cent)	$219,000 00	$7,300 00
Commonwealth grant (3½ per cent)	142,000 00	1,313 32
	–	$10,613 32

[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College recei[v]
two-thirds of the income from the same.

Burnham Emergency Fund.

	Market Value Dec. 1, 1922.	Par Value.	Income
Two bonds American Telephone and Telegraph Company 4s at $910	$1,820 00	$2,000 00	$80 0
Two bonds Western Electric Company 5s at $1,000	2,000 00	2,000 00	100 0
One United States Liberty Bond 4¼s, $980	490 00	500 00	21 2
Louisville Gas & Electric Co. 7s, $1,000	500 00	500 00	35 0
	$4,810 00	$5,000 00	$236 2
Unexpended balance Dec. 1, 1921	–	–	325 8
	–	–	$562 0
Disbursements for fiscal year ending November 30, 1922	–	–	70 0
Cash on hand November 30, 1922	–	–	$492 0

Library Fund.

Five bonds New York Central & Hudson River Railroad Company 4s at $920	$4,600 00	$5,000 00	$200 0
Five bonds Lake Shore & Michigan Southern Railroad Company 4s at $940	4,700 00	5,000 00	200 0
Two shares New York Central & Hudson River Railroad Company Stock at $96	192 00	200 00	10 0
Amherst Savings Bank, deposit	167 77	167 77	8 0
	$9,659 77	$10,367 77	$418 0
Returned Funds	–	–	1 1
	–	$10,367 77	$419 1
Disbursements for fiscal year, November 30, 1922	–	–	419 1

Special Funds.

Endowed Labor Fund (the Gift of a Friend of the College).

Two bonds American Telephone and Telegraph Company 4s at $910	$1,820 00	$2,000 00	$80 0
Two bonds Lake Shore & Michigan Southern Railroad Company 4s at $940	1,880 00	2,000 00	80 0
One bond New York Central Railroad debenture 4s	920 00	1,000 00	40 0
One bond Louisville Gas and Electric 7s	1,000 00	1,000 00	70 0
Amherst Savings Bank, deposit	143 39	143 39	6 8
One United States Liberty Bond 4¼	980 00	1,000 00	42 5
	$6,743 39	$7,143 39	$319 3
Unexpended balance December 1, 1921	–	–	10 9
Cash on hand November 30, 1922	–	–	$330 3

SPECIAL FUNDS — *Continued.*

Whiting Street Scholarship Fund.

	Market Value Dec. 1, 1922.	Par Value.	Income.
ne bond New York Central debenture 4s	$920 00	$1,000 00	$40 00
mherst Savings Bank, deposit	271 64	271 64	13 02
	$1,191 64	$1,271 64	$53 02
nexpended balance December 1, 1921	–	–	502 63
Cash on hand November 30, 1922	–	–	$555 65

Hills Fund.

wo United States Liberty Bonds 4¼ at $980	$1,960 00	$2,000 00	$85 00
ne bond American Telephone and Telegraph Company 4s, at $910	910 00	1,000 00	40 00
ne bond New York Central & Hudson River Railroad debenture 4s at $920	920 00	1,000 00	40 00
ne bond New York Central Railroad debenture 4s at $920	920 00	1,000 00	40 00
hree bonds Pacific Telephone and Telegraph Company 5s, at $970	2,910 00	3,000 00	150 00
ne bond Western Electric Company 5s at	1,000 00	1,000 00	50 00
oston & Albany Railroad stock 3⅝ bonds at $145	526 00	362 00	31 68
mherst Savings Bank, deposit	72 75	72 75	3 46
lectric Securities Company bonds, 1⁹⁄₅₀ bonds, $950	1,121 00	1,180 00	59 00
wo bonds Louisville Gas and Electric 7s at $1,000	2,000 00	2,000 00	140 00
	$12,339 75	$12,614 75	$639 14
nexpended balance Dec. 1, 1921	–	–	1,681 47
	–	–	$2,320 61
isbursements for fiscal year ending Nov. 30, 1922	–	–	401 79
Cash on hand November 30, 1922	–	–	$1,918 82

Mary Robinson Fund.

mherst Savings Bank deposit	$142 00	$142 00	$6 81
oston & Albany Railroad stock ⅜ share at $145	54 00	38 00	3 32
lectric Securities Company bonds, ⁴¹⁄₅₀ bond at $950	779 00	820 00	41 00
	$975 00	$1,000 00	$51 13
nexpended balance Dec. 1, 1921	–	–	393 48
Cash on hand Nov. 30, 1922	–	–	$444 61

Grinnell Prize Fund.

en shares New York Central & Hudson River Railroad stock at $96	$960 00	$1,000 00	$50 00
nexpended balance Dec. 1, 1921	–	–	245 74
	$960 00	$1,000 00	$295 74
isbursements for Prizes	–	–	50 00
Cash on hand Nov. 30, 1922	–	–	$245 74

Students' Loan Fund of the Massachusetts Agricultural Club.

irst National Bank	$500 00	$500 00	–
isbursements for fiscal year ending Nov. 30, 1922	–	150 00	–
Cash on hand Nov. 30, 1922	–	$350 00	–

Special Funds — *Continued.*

Gassett Scholarship Fund.

	Market Value Dec. 1, 1922.	Par Value.	Income.
One bond New York Central & Hudson River Railroad debenture 4s at $920	$920 00	$1,000 00	$40 0
Amherst Savings Bank deposit	11 64	11 64	5
	$931 64	$1,011 64	$40 5
Unexpended balance Dec. 1, 1921	–	–	385 2
Cash on hand Nov. 30, 1922	–	–	$425 7

Massachusetts Agricultural College (Investment).

One share New York Central & Hudson River Railroad stock $96	$96 00	$100 00	$5 0
Unexpended balance Dec. 1, 1921	–	–	105 4
Cash on hand Nov. 30, 1922	–	–	$110 4

Danforth Keyes Bangs Fund.

Two bonds Pacific Telephone and Telegraph Company 5s at $970	$1,940 00	$2,000 00	$100 0
Two bonds Union Electric Light and Power Company 5s at $940	1,880 00	2,000 00	100 0
Two bonds American Telephone and Telegraph Company 4s at $910	1,820 00	2,000 00	80 0
One United States Liberty Bond 4¼s $980	980 00	1,000 00	42 5
Interest from student loans	–	–	90 9
	$6,620 00	$7,000 00	$413 4
Unexpended balance Dec. 1, 1921	–	–	1,375 2
	–	–	$1,788 6
Total loans made to students during fiscal year . . . $4,551 00	–	–	–
Cash received on account of student loans . . . 2,750 00	–	–	–
Excess of loans made over accounts paid by students	–	–	1,801 0
Cash overdrawn Nov. 30, 1922	–	–	—$12 3

John C. Cutter Fund.

One bond Pacific Telephone and Telegraph Company 5s at $970	$970 00	$1,000 00	$50 0
Unexpended balance Dec. 1, 1921	–	–	104 1
	$970 00	$1,000 00	$154 12
Disbursements for fiscal year ending Nov. 30, 1922	–	–	87 69
Cash on hand Nov. 30, 1922	–	–	$66 43

William R. Sessions Fund.

One $500.00 bond New York Central & Hudson River Railroad 6s $1,040	$520 00	$500 00	$30 00
Three United States Liberty Bonds, two at $1,000.00 and one at $500.00, 4¼s at $980	2,450 00	2,500 00	106 25
One bond Adirondack Light and Power Company 6s	1,010 00	1,000 00	60 00
One bond Southern Illinois Light and Power Company 6s	1,000 00	1,000 00	–
	$4,980 00	$5,000 00	$196 25
Toledo Light and Power Company	–	–	35 00
Conemaugh Light and Power Company	–	–	80 00
Earnings from exchange of bonds	–	–	20 92
Unexpended balance Dec. 1, 1921	–	–	41 39
	–	–	$373 56
Disbursements for fiscal year ending Nov. 30, 1922	–	–	33 50
Cash on hand Nov. 30, 1922	–	–	$340 06

SPECIAL FUNDS — *Concluded.*

Alvord Dairy Scholarship Fund.

	Market Value Dec. 1, 1922.	Par Value.	Income.
United States Liberty Bond 4¼	$980 00	$1,000 00	$42 50
bond Southern Illinois Light and Power Co. 7s	1,015 00	1,000 00	–
bonds Great Western Power Co. 6s $1,000	2,000 00	2,000 00	90 00
	$3,995 00	$4,000 00	$132 50
do Light and Power Company	–	–	35 00
maugh Light and Power Company	–	–	160 00
ings from exchange of bonds	–	–	64 00
xpended balance Dec. 1, 1921	–	–	768 61
ash on hand Nov. 30, 1922	–	–	$1,160 11

MARY OF BALANCE ON HAND OF THE INCOME FROM FUNDS HELD IN TRUST BY THE MASSACHUSETTS AGRICULTURAL COLLEGE.

ham Emergency Fund	$492 06
owed Labor Fund	330 31
ting Street Scholarship Fund	555 65
Fund	1,918 82
y Robinson Fund	444 61
nell Prize Fund	245 74
ett Scholarship Fund	425 78
sachusetts Agricultural College Investment Fund	110 45
orth Keyes Bangs Fund	—12 35
C. Cutter Fund	66 43
iam R. Sessions Fund	340 06
rd Dairy Scholarship Fund	1,160 11
sachusetts Agricultural Club	350 00
	$6,427 67
	350 00
	$6,077 67

J. D. W. FRENCH FUND.

ingham National Bank		$6,847 55
ester County Institution for Savings		1,728 82
k Five Cents Savings Bank		391 16
ury Savings Bank		1,685 35
		$10,652 88
amount withdrawn from Framingham National Bank		500 00
		$10,152 88
nt expended for live stock exhibit at Eastern States Fair	455 20	
on hand		44 80
Total amount available		$10,197 68

hereby certify that I have this day examined the Massachusetts Agricultural College unt, as reported by the Treasurer, Fred C. Kenney, for the year ending November 30, 2 All bonds and investments are as represented in the Treasurer's report. All disments are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

J. 2, 1923.

History of Special Funds.

Burnham emergency fund:
A bequest of $5,000 from T. O. H. P. Burnham of Boston made without any conditions. The trustees of the college directed that $1,000 of this fund should be used in the purchase of the Newell land and Goessmann Library. The fund now shows an investment of $4,000

Library fund:
The library of the college at the present time contains 69,272 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887, Elizur Smith of Lee, Mass., gave $1,315. These were the largest bequests and now amount to . . 10,000

Endowed labor fund:
Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students. 5,000

Whiting Street scholarship fund:
Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship 1,000

Hills fund:
Gift of Leonard M. and Henry F. Hills of Amherst, Mass., in 1867, to establish and maintain a botanic garden 10,000

Mary Robinson fund:
Gift of Miss Mary Robinson of Medfield, in 1874, for scholarship . . . 1,000

Grinnell prize fund:
Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York 1,000

Gassett scholarship fund:
Gift of Henry Gassett of Boston, the income to be used for scholarship . . 1,000

Massachusetts Agricultural College investment fund:
Investment made by vote of trustees in 1893 to purchase one share of New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate 100

Danforth Keyes Bangs fund:
Gift of Louisa A. Baker of Amherst, Mass., April 14, 1909, the income thereof to be used annually in aiding poor, industrious, and deserving students to obtain an education in said college 6,000

John C. Cutter fund:
Gift of Dr. John C. Cutter of Worcester, Mass., an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene 1,000

Alvord dairy scholarship fund:
Gift of Henry E. Alvord, who was the first instructor in military tactics, 1869–71, and a professor of agriculture, 1885–87, at this institution. The income of this fund is to be applied to the support of any worthy student of said college, graduate or postgraduate, who may be making a specialty of the study of dairy husbandry (broadly considered) with the intention of becoming an investigator, teacher or special practitioner in connection with the dairy industry, provided that no benefits arising from such fund shall at any time be applied to any person who then uses tobacco in any form, or fermented or spirituous beverages, or is known to have done so within one year next preceding 4,000

William R. Sessions fund:
In accordance with the request of my deceased wife, Clara Markham Sessions, made in her last will, I bequeath to the trustees of the Massachusetts Agricultural College, Amherst, Mass., the sum of $5,000, it being the amount received by me from the estate of the said Clara Markham Sessions. The said $5,000 to be kept by the said trustees a perpetual fund, the income from which shall be for the use of the Massachusetts Agricultural College; and according to the further request of my deceased wife, made in her last will, this is to be known as the William R. Sessions fund, and is to be a memorial of William R. Sessions; and it is my special request that the said trustees shall make record of the fact that this fund came from the estate of my deceased wife, Clara Markham Sessions, in accordance with her request made in her last will 5,000

J. D. W. French Fund	10,000 00	
Massachusetts Agricultural Club	500 00	10,500
		$59,600

FRED C. KENNEY,
Treasurer.

PUBLIC DOCUMENT No. 31

MASSACHUSETTS AGRICULTURAL COLLEGE

CATALOGUE, 1922-1923

PUBLIC DOCUMENT No. 31

THE M. A. C. BULLETIN

AMHERST, MASSACHUSETTS

VOLUME XV JANUARY, 1923 NUMBER I

PUBLISHED EIGHT TIMES A YEAR BY THE MASSACHUSETTS AGRICULTURAL COLLEGE: JAN., FEB., MARCH, MAY, JUNE, SEPT., OCT., NOV. ENTERED AT THE POST OFFICE, AMHERST, MASS., AS SECOND CLASS MATTER

THE SIXTIETH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE

PART II.—CATALOGUE OF THE COLLEGE FOR 1922-1923

Publication of this Document
approved by the
Supervisor of Administration.

The Commonwealth of Massachusetts

Department of Education, Boston, Jan. 31, 1923.

To the Honorable Senate and House of Representatives.

Gentlemen: — In accordance with the provisions of section 8 of chapter 75 of the General Laws, I transmit to you herewith, for the use of the General Court, the annual report of the Massachusetts Agricultural College for the year ending Nov. 30, 1922.

Respectfully yours,

PAYSON SMITH,
Commissioner of Education.

The Commonwealth of Massachusetts

Massachusetts Agricultural College,
Amherst, Nov. 30, 1922.

To the Commissioner of Education.

Sir: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith Part II of the sixtieth annual report of the trustees for the fiscal year ended Nov. 30, 1922, this being the catalogue of the college.

Respectfully yours,

KENYON L. BUTTERFIELD,
President.

CONTENTS.

The Massachusetts Agricultural College

Without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and mechanic arts in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. — *Act of Congress, July 2, 1862.*

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow. When deemed necessary, additional announcements are made in a supplementary bulletin, published in the spring.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue.

Calendar.

1922–23.

Regular and Two-Year Courses.

1922.

September 27, Wednesday, 1.30 p.m.	Fall term begins; assembly.
October 12, Thursday	Holiday, Columbus Day.
November 29–December 4, Wednesday, 12 m.–Monday, 7.30 a.m.	Thanksgiving recess.
December 22, Friday, 5 p.m.	Fall term ends.

1923.

January 2, Tuesday, 7.30 a.m.	Winter term begins.
February 22, Thursday	Holiday, Washington's Birthday.
March 23, Friday, 5 p.m.	Winter term ends.
March 26, Monday, 1 p.m.	Spring term begins.
April 19, Thursday	Holiday, Patriots' Day.
May 30, Wednesday	Holiday, Memorial Day.
June 9–11, Saturday–Monday	Commencement.
June 14–16, Thursday–Saturday	Entrance examinations.
September 19–22, Wednesday–Saturday	Entrance examinations.
September 26, Wednesday, 1.30 p.m.	Fall term begins; assembly.
October 12, Friday	Holiday, Columbus Day.
November 28–December 3, Wednesday, 12 m.–Monday, 7.30 a.m.	Thanksgiving recess.
December 21, Friday, 5 p.m.	Fall term ends.
December 31, Monday, 1 p.m.	Winter term begins.

Massachusetts Agricultural College.

History. — The Massachusetts Agricultural College was organized under the national land grant act of 1862. This legislation is also known as the Morrill act, the original bill having been framed by Justin Smith Morrill, Senator from Vermont, and its final enactment secured under his leadership. It provided that public lands be assigned to the several States and territories, the funds from the sale of which were to be used to establish and maintain colleges of agriculture and mechanic arts. The Massachusetts Agricultural College was among the first of these institutions established. When this act was passed the Massachusetts Institute of Technology was already organized, and the State of Massachusetts definitely decided that the instruction in the mechanic arts should be at the institute, and that the new institution should confine its work to agriculture. On this account the Massachusetts Agricultural College has the unique distinction of being the only separate agricultural college in the country.

In 1863 the State of Massachusetts accepted the provisions of the Morrill act and incorporated the Agricultural College. The location at Amherst was decided only after long and careful study by the original Board of Trustees. The college was formally opened to students on the 2d of October, 1867, with a faculty of four teachers and with four wooden buildings.

The Massachusetts Legislature has granted money for the erection of practically all of the buildings now on the grounds. In view of the fact that the annual income from the original endowment has been only a few thousand dollars, it has been necessary for the State to assume responsibility for the current expenses of the institution.

Organization. — The college is a State institution, and as such is subject to the laws governing and the rules applying to all State departments and institutions. The work of the college is directed by a board of eighteen trustees. Four of these are ex-officio members, — the Governor of the State, the Commissioner of Education, the Commissioner of Agriculture and the president of the college. The other fourteen members are appointed by the Governor for terms of seven years each, or two each year. The immediate control of the institution is vested in the president of the college. The administrative officers, having supervision of the various departments of activity, are directly responsible to the president.

In carrying out its purpose the college has organized three distinct yet correlated types of work, — namely, research, resident instruction and extension service.

Research. — Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established and supported as a department of the college.

For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the Federal government. In 1906 the Federal government largely increased its support on condition that the money thus provided should be used only for research. The station now receives about three-fourths of its support from the State.

The station is under the direct supervision of the Board of Trustees; the chief officer is the director, who is responsible to the president. It is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of these departments are heads of corresponding departments in the college. The station publishes numerous bulletins and two annual reports, one scientific, the other popular. These publications are free and circulate extensively.

Resident Instruction. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The chief aim of the institution, through its resident instruction, is to prepare men and women for the agricultural vocations. The term "agricultural vocations" is here used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, floriculture, landscape gardening and forestry. Students are also trained for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural colleges and high schools, and for scientific work in chemistry, entomology, botany and microbiology.

Though training for the agricultural vocations is thus the chief concern of the college, students should find the course one that trains them admirably for pursuits in which the sciences are an essential preparation. The course of study aims also to combine an adequate general education with specialized technical and practical training.

Four-year Courses. — Twenty-nine teaching departments offer instruction in agriculture, horticulture, sciences, the humanities, rural social science and rural home making. A system of major courses permits the student to elect major work in one of eighteen departments, and to specialize in it and allied subjects for a period of two years. The degree of bachelor of science is granted on the satisfactory completion of the four years' work of collegiate grade.

Short Courses. — In order to extend the advantages of the institution to those men and women who cannot or do not care to take advantage of the four-year course, various short courses are offered. Chief among these are a two-year course in practical agriculture, a summer school of agriculture and country life, and a winter school of agriculture.

Graduate School. — The graduate school is organized to provide the necessary training for scientific leadership in agriculture and allied sciences. The degrees of master of agriculture, master of landscape architecture, master of science, doctor of agriculture and doctor of philosophy may be earned upon the completion of satisfactory study, research and thesis.

The Extension Service. — The extension service is an organized effort

to carry systematic and dignified instruction to the thousands of people throughout the State who are unable, for various reasons, to take advantage of the regular courses offered at the college. It is in reality the "carrying of the college to the people of the State." Every department of the institution, in so far as the regular teaching and research work will permit, contributes what it can to this work. There is also a regular staff of extension workers whose sole business it is to present the instruction of the college to individuals and various organizations throughout the State.

Location and Equipment. — The Agricultural College is located in the town of Amherst. The grounds comprise more than 650 acres, lying about a mile north of the village center. The college has also a demonstration forest of 755 acres, located 6 miles north of the campus. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is 97 miles from Boston, and may be reached by the Central Massachusetts division of the Boston & Maine Railroad, or by the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

Military Drill. — By Federal law military drill is required of all regular students attending the Massachusetts Agricultural College.

THE TRUSTEES.

ORGANIZATION OF 1922.

MEMBERS OF THE BOARD.

	TERM EXPIRES
CHARLES A. GLEASON of North Brookfield	1923
JAMES F. BACON of Boston	1923
FRANK GERRETT of Greenfield	1924
HAROLD L. FROST of Arlington	1924
CHARLES H. PRESTON of Danvers	1925
CARLTON D. RICHARDSON of West Brookfield	1925
DAVIS R. DEWEY of Cambridge	1926
JOHN F. GANNON of Pittsfield	1926
ARTHUR G. POLLARD of Lowell	1927
GEORGE H. ELLIS of West Newton	1927
ELMER D. HOWE of Marlborough	1928
ATHERTON CLARK of Newton	1928
NATHANIEL I. BOWDITCH of Framingham	1929
WILLIAM WHEELER of Concord	1929

MEMBERS EX OFFICIO.

His Excellency Governor CHANNING H. COX, *President of the Board of T ustees.*
KENYON L. BUTTERFIELD, *President of the College.*
PAYSON SMITH, *State Commissioner of Education.*
ARTHUR W. GILBERT, *State Commissioner of Agriculture.*

OFFICERS OF THE TRUSTEES.

His Excellency Governor CHANNING H. COX of Boston, *President.*
CHARLES A. GLEASON of North Brookfield, *Vice-President.*
RALPH J. WATTS of Amherst, *Secretary.*
FRED C. KENNEY of Amherst, *Treasurer.*
CHARLES A. GLEASON of North Brookfield, *Auditor.*

STANDING COMMITTEES OF THE TRUSTEES.[1]

Committee on Finance.

CHARLES A. GLEASON, *Chairman.*
GEORGE H. ELLIS.
NATHANIEL I. BOWDITCH.
ARTHUR G. POLLARD.
CARLTON D. RICHARDSON.
ATHERTON CLARK.

Committee on Course of Study and Faculty.

WILLIAM WHEELER, *Chairman.*
ELMER D. HOWE.
JAMES F. BACON.
PAYSON SMITH.
DAVIS R. DEWEY.
JOHN F. GANNON.
ARTHUR W. GILBERT.

Committee on Farm.

NATHANIEL I. BOWDITCH, *Chairman.*
FRANK GERRETT.
GEORGE H. ELLIS.
ARTHUR W. GILBERT.
CARLTON D. RICHARDSON.

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[1] The president of the college is ex-officio member of each committee.

Committee on Horticulture.

Harold L. Frost, *Chairman.*
Charles A. Gleason.
Elmer D. Howe.
Atherton Clark.
Charles H. Preston.

Committee on Experiment Department.

Charles H. Preston, *Chairman.*
Arthur W. Gilbert.
Arthur G. Pollard.
Harold L. Frost.
Carlton D. Richardson.

Committee on Buildings and Arrangement of Grounds.

George H. Ellis, *Chairman.*
Frank Gerrett.
William Wheeler.
James F. Bacon.
Charles H. Preston.
Atherton Clark.

Committee on Extension Service.

Elmer D. Howe, *Chairman.*
George H. Ellis.
Harold L. Frost.
Davis R. Dewey.
Nathaniel I. Bowditch.
John F. Gannon.
Arthur W. Gilbert.

Officers of the Institution.

As of Nov. 1, 1922.

OFFICERS OF GENERAL ADMINISTRATION.

Kenyon L. Butterfield, A.M., LL.D. . . . . President's House.
President of the College.

Henry S. Green, A.B., LL.D. . . . . Mount Pleasant.
Librarian of the College.

Philip B. Hasbrouck, B.Sc. . . . . 31 Fearing Street.
Registrar of the College.

Sidney B. Haskell, B.Sc. . . . . 2 Mount Pleasant.
Director of the Experiment Station.

Fred C. Kenney . . . . Mount Pleasant.
Treasurer of the College.

Edward M. Lewis, A.M. . . . . National Bank Block.
Dean of the College.

Charles E. Marshall, Ph.D. . . . . 44 Sunset Avenue.
Director of the Graduate School.

Richard A. Mellen, B.Sc. . . . . Fearing Street.
Field Agent.

John Phelan, A.M. . . . . Mount Pleasant.
Director of Short Courses.

Ralph J. Watts, B.Sc. . . . . 101 Butterfield Terrace.
Secretary of the College.

John D. Willard, B.A. . . . . 31 Lincoln Avenue.
Director of the Extension Service.

THE FACULTY OF INSTRUCTION.

Kenyon L. Butterfield, A.M., LL.D. . . . . President's House.
President of the College and Head of the Division of Rural Social Science.

Max F. Abell, B.Sc. . . . . North Amherst.
Assistant Professor of Farm Management.

George W. Alderman, B.A. . . . . North Pleasant Street.
Instructor in Physics.

Charles P. Alexander, Ph.D. . . . . 120 Pleasant Street.
Assistant Professor of Entomology.

Edgar L. Ashley, A.M. . . . . Amherst House.
Professor of German.

Roy C. Avery, M.Sc. . . . . 15 Spring Street.
Instructor in Microbiology.

Luther Banta, B.Sc. . . . . Sunset Avenue.
Assistant Professor of Poultry Husbandry.

Mary A. Bartley . . . . 50 Pleasant Street.
Instructor in Home Economics.

Arthur B. Beaumont, Ph.D. . . . . 51 Amity Street.
Professor of Agronomy and Head of Department.

Carl M. Bogholt, B.Sc. . . . . The Davenport.
Instructor in English.

Thomas Brady, Jr., Captain, Cavalry, U. S. A. . . . . . Kendrick Place.
Assistant Professor of Military Science and Tactics.

Alexander E. Cance, Ph.D. . . . . 9 Fearing Street.
Professor of Agricultural Economics and Head of Department.

Joseph S. Chamberlain, Ph.D. . . . . Mount Pleasant.
Professor of Organic and Agricultural Chemistry.

Walter W. Chenoweth, M.Sc. . . . . North Amherst.
Professor of Horticultural Manufactures and Head of Department.

Orton L. Clark, B.Sc. . . . . 12 College Street.
Assistant Professor of Botany.

Herbert L. Collins, B.Sc. . . . . 35 North Prospect Street.
Instructor in Physical Education.

G. Chester Crampton, Ph.D. . . . . Fernald Hall.
Professor of Insect Morphology.

William H. Davis, Ph.D. . . . . 8 Allen Street.
Assistant Professor of Botany.

Llewellyn L. Derby . . . . 25 Taylor Street, Holyoke.
Instructor in Physical Education.

Brooks D. Drain, B.Sc. . . . . 50 Pleasant Street.
Assistant Professor of Pomology.

Henry T. Fernald, Ph.D. . . . . 44 Amity Street.
Professor of Entomology, Head of Department, Chairman of Division of Science.

James A. Foord, M.Sc.Agr. . . . . 54 Lincoln Avenue.
Professor of Farm Management, Head of Department, Head of Division of Agriculture.

Philip E. Foss, B.Sc. . . . . 42 Lincoln Avenue.
Instructor in Zoölogy.

Willard K. French, B.Sc. . . . . 10 Nutting Avenue.
Assistant Professor of Pomology.

George E. Gage, Ph.D. . . . . The Davenport.
Professor of Animal Pathology and Head of Department of Veterinary Science and Animal Pathology.

Mary E. M. Garvey, B.Sc. . . . . 29 South Prospect Street.
Instructor in Microbiology.

Guy V. Glatfelter, M.Sc. . . . . 10 Kendrick Place.
Assistant Professor of Animal Husbandry.

Helena T. Goessmann, M.Ph. . . . . 35 South Pleasant Street.
Instructor in English.

Clarence E. Gordon, Ph.D. . . . . 38 Lincoln Avenue.
Professor of Zoölogy and Geology, and Head of Department.

Harold M. Gore, B.Sc. . . . . 70 Lincoln Avenue.
Assistant Professor of Physical Education.

Charles H. Gould, B.Sc. . . . . 170 South Pleasant Street.
Assistant Professor of Pomology.

John C. Graham, B.Sc.Agr. . . . . 68 Lincoln Avenue.
Professor of Poultry Husbandry and Head of Department.

Emory E. Grayson, B.Sc. . . . . Belchertown.
Instructor in Physical Education.

Laurence R. Grose, A.B., M.F. . . . . 45 Amity Street.
Professor of Forestry and Head of Department.

Christian I. Gunness, B.Sc. . . . . 105 Butterfield Terrace.
Professor of Rural Engineering and Head of Department.

Margaret Hamlin, B.A. . . . . 12 North East Street.
Agricultural Counsellor for Women.

Elmer A. Harrington, Ph.D. . . . . 7 Allen Street.
Professor of Physics.

Roy D. Harris, B.Sc. . . . . 12 Chestnut Street.
Assistant Professor of Vegetable Gardening.

Arthur K. Harrison . . . . 8 Allen Street.
Assistant Professor of Landscape Gardening.

William R. Hart, M.A., LL.B. . . . . 97 Pleasant Street.
Professor of Agricultural Education and Head of Department.

Philip B. Hasbrouck, B.Sc. . . . . 31 Fearing Street.
Professor of Physics and Head of Department.

Curry S. Hicks, B.Pd. . . . . The Davenport.
Professor of Physical Education and Hygiene, and Head of Department.

Mrs. Curry S. Hicks[1] . . . . The Davenport.
Instructor in Physical Education.

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[1] Temporary.

Arao Itano, Ph.D. . . . . Amherst House
Assistant Professor of Microbiology.
Henry F. Judkins, B.Sc. . . . . 103 Butterfield Terrace
Professor of Dairying and Acting Head of Department.
Arthur N. Julian, A.B. . . . . 4 Fairview Way
Assistant Professor of German.
Herman Kobbe, Major, Cavalry, U. S. A. . . . . Sunset Avenue
Assistant Professor of Military Science and Tactics.
Marshall O. Lanphear, B.Sc. . . . . 4 Nutting Avenue
Instructor in Agronomy.
John B. Lentz, A.B., V.M.D. . . . . 3 Dana Street
Assistant Professor of Veterinary Science and College Veterinarian.
Edward M. Lewis, A.M. . . . . National Bank Block
Professor of Languages and Literature, Head of Department and Acting Head of Division of Humanities.
Joseph B. Lindsey, Ph.D. . . . . 47 Lincoln Avenue
Goessmann Professor of Agricultural Chemistry and Head of Department.
William L. Machmer, M.A. . . . . 25 Amity Street
Professor of Mathematics and Assistant Dean.
Warren B. Mack, B.Sc.[1] . . . . 84 Pleasant Street
Instructor in Pomology.
Alexander A. Mackimmie, A.M. . . . . North Amherst
Professor of French.
John J. Maginnis, B.Sc. . . . . 35 North Prospect Street
Instructor in Agricultural Economics.
Charles E. Marshall, Ph.D. . . . . 44 Sunset Avenue
Professor of Microbiology and Head of Department.
Frederick A. McLaughlin, B.Sc. . . . . 4 Nutting Avenue.
Assistant Professor of Botany
Charles A. Michels, M.Sc. . . . . 9 Fearing Street
Assistant Professor of Agronomy.
Frank C. Moore, A.B. . . . . 10 Allen Street
Assistant Professor of Mathematics.
Richard T. Muller, M.Sc.[1] . . . . 45 East Pleasant Street.
Assistant Professor of Floriculture.
John B. Newlon . . . . North Amherst.
Instructor in Rural Engineering.
Joseph F. Novitski, B.Sc.[2] . . . . 4 Tyler Place.
Instructor in Rural Sociology.
A. Vincent Osmun, M.Sc. . . . . 16 Northampton Road.
Professor of Botany and Head of Department.
John E. Ostrander, A.M., C.E. . . . . 33 North Prospect Street.
Professor of Mathematics and Head of Department.
Laurence H. Parker, A.B. . . . . The Davenport.
Professor of Citizenship and Acting Head of Department of Economics and Sociology.
Charles H. Patterson, A.M. . . . . 26 Lincoln Avenue.
Professor of English.
Harlow L. Pendleton, B.Sc. . . . . 105 Main Street.
Instructor in Dairying.
Charles A. Peters, Ph.D. . . . . Sunset Place.
Professor of Inorganic and Soil Chemistry.
John Phelan, A.M. . . . . 3 Mount Pleasant.
Professor of Rural Sociology and Head of Department.
Norman E. Phillips, B.Sc.[3] . . . . 18 Northampton Road.
Assistant Professor of Beekeeping.
Wayland R. Porter, B.Sc. . . . . Belchertown Road.
Instructor in Mathematics.
Walter E. Prince, A.M. . . . . 29 Amity Street.
Assistant Professor of English.
George F. Pushee . . . . North Amherst.
Instructor in Rural Engineering.

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[1] Paid from Federal funds for vocational education.
[2] On leave of absence.
[3] Resigned October 31.

Frank P. Rand, A.M. Assistant Professor of English.	North Amherst.
Victor A. Rice, B.Sc.Agr. Assistant Professor of Animal Husbandry.	10 Woodside Avenue.
William F. Robertson, B.Sc. Instructor in Horticultural Manufactures.	10 Nutting Street.
Roland W. Rogers, B.Sc. Assistant Professor of Horticulture.	32 North Prospect Street.
Schuyler M. Salisbury, B.Sc.Agr. Professor of Animal Husbandry and Head of Department.	12 Nutting Avenue.
William C. Sanctuary, B.Sc. Professor of Poultry Husbandry.	South Pleasant Street.
Donald W. Sawtelle, M.Sc. Assistant Professor of Agricultural Economics.	13 Fearing Street.
Fred C. Sears, M.Sc. Professor of Pomology and Head of Department.	Mount Pleasant.
Paul Serex, Jr., M.Sc. Assistant Professor of Chemistry.	Lincoln Avenue.
Frederick E. Shnyder, A.B., Major, Cavalry, U. S. A. Professor of Military Science and Tactics.	Amherst House.
James V. V. Shufelt, B.Sc., Captain, Cavalry, U. S. A. Assistant Professor of Military Science and Tactics.	Mount Pleasant.
Newell L. Sims, Ph.D. Professor of Rural Sociology.	16 North Prospect Street.
Edna L. Skinner, B.Sc. Professor of Home Economics, Head of Department, Adviser of Women.	50 Lincoln Avenue.
Richard W. Smith, Jr., B.Sc. Instructor in Dairying.	17 Fearing Street.
Grant B. Snyder, B.Sc. Agr. Instructor in Vegetable Gardening.	17 Fearing Street.
James L. Strahan, M.Sc. Assistant Professor of Rural Engineering.	50 Amity Street.
Lewis W. Taylor, B.Sc. Instructor in Poultry Husbandry.	Poultry Plant.
Charles H. Thayer Instructor in Agronomy.	South East Street.
Clark L. Thayer, B.Sc. Professor of Floriculture and Head of Department.	North Amherst.
Weston C. Thayer, B.Sc. Instructor in Animal Husbandry.	14 Nutting Avenue.
Guy A. Thelin, B.Sc. Instructor in Agronomy.	21 Pleasant Street.
Paul E. Thissell, A.B. Instructor in French.	81 Pleasant Street.
Charles H. Thompson, M.Sc. Assistant Professor of Horticulture.	Mount Pleasant.
Harold F. Tompson, B.Sc. Professor of Vegetable Gardening and Head of Department.	Lexington.
Ray E. Torrey, Ph.D. Assistant Professor of Botany.	Care of Mrs. H. D. Fearing.
Paul W. Viets Supervisor of Placement Training.	5 Kendrick Place.
Frank A. Waugh, M.Sc. Professor of Landscape Gardening, Head of Department, Head of Division of Horticulture.	Campus.
Winthrop S. Welles, B.Sc. Professor of Agricultural Education.	23 Lincoln Avenue.
Charles Wellington, Ph.D. Professor of Chemistry.	34 Amity Street.
T. George Yaxis, M.Sc. Assistant Professor of Dairying.	5 Tillson Court.

THE EXPERIMENT STATION STAFF.

KENYON L. BUTTERFIELD, A.M., LL.D. . . . . President's House.
President of the College.

SIDNEY B. HASKELL, B.Sc. . . . . 2 Mount Pleasant.
Director.

JAMES R. ALCOCK . . . . North Amherst.
Laboratory Assistant in Animal Nutrition.

HARRY L. ALLEN . . . . 89 Main Street.
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PAUL J. ANDERSON, Ph.D. . . . . 25 Lincoln Avenue.
Research Professor of Botany.

JOHN G. ARCHIBALD, B.Sc.Agr. . . . . West Pelham.
Assistant Research Professor of Chemistry.

ALYN S. BALL . . . . 94 Main Street.
Laboratory Assistant in Botany.

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Professor of Agronomy and Head of Department.

ARTHUR I. BOURNE, B.A. . . . . 12 East Pleasant Street.
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Professor of Agricultural Economics and Head of Department.

WALTER W. CHENOWETH, M.Sc. . . . . North Amherst.
Professor of Horticultural Manufactures and Head of Department.

ORTON L. CLARK, B.Sc. . . . . 12 College Street.
Assistant Professor of Botany.

ROBERT L. COFFIN . . . . 19 Phillips Street.
Investigator in Agriculture.

CHARLES O. DUNBAR, B.Sc. . . . . 84 Pleasant Street.
Investigator in Chemistry.

HENRY T. FERNALD, Ph.D. . . . . 44 Amity Street.
Professor of Entomology and Head of Department.

JAMES A. FOORD, M.Sc.Agr. . . . . 54 Lincoln Avenue.
Professor of Farm Management and Head of Department.

HENRY J. FRANKLIN, Ph.D. . . . . East Wareham.
Assistant Research Professor in charge of Cranberry Substation.

ARTHUR P. FRENCH, B.Sc. . . . . 5 Hitchcock Street.
Investigator in Pomology.

GEORGE E. GAGE, Ph.D. . . . . The Davenport.
Professor of Animal Pathology and Head of Department of Veterinary Science and Animal Pathology.

EDWIN F. GASKILL, M.Sc. . . . . North Pleasant Street.
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JOHN C. GRAHAM, B.Sc. . . . . 68 Lincoln Avenue.
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FRANK A. HAYS, Ph.D. . . . . Sunset Avenue.
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ARAO ITANO, Ph.D. . . . . Amherst House.
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LORIAN P. JEFFERSON, M.A. . . . . The Davenport.
Assistant Research Professor of Agricultural Economics.

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Professor of Dairying and Acting Head of Department.

WEBSTER S. KROUT, M.A. . . . . Lexington.
Assistant Research Professor of Botany.

JOHN B. LENTZ, A.B., V.M.D. . . . . 42 Lincoln Avenue.
Assistant Research Professor of Veterinary Science.

JOSEPH B. LINDSEY, Ph.D. . . . . 47 Lincoln Avenue.
Vice-Director, Professor of Chemistry and Head of Department.
CHARLES E. MARSHALL, Ph.D. . . . . 44 Sunset Avenue.
Professor of Microbiology and Head of Department.
FRED W. MORSE, M.Sc. . . . . 40 Pleasant Street.
Research Professor of Chemistry.
A. VINCENT OSMUN, M.Sc. . . . . 16 Northampton Road.
Professor of Botany and Head of Department.
JOHN E. OSTRANDER, A.M., C.E. . . . . 33 North Prospect Street.
Meteorologist.
NORMAN J. PYLE, D.V.M.[1] . . . . – –
Assistant Research Professor of Avian Pathology.
RUBY SANBORN, A.B. . . . . 45 Pleasant Street.
Investigator in Poultry Husbandry.
FRED C. SEARS, M.Sc. . . . . Mount Pleasant.
Professor of Pomology and Head of Department.
JACOB K. SHAW, Ph.D. . . . . 5 Fairview Way.
Research Professor of Pomology.
HAROLD F. TOMPSON, B.Sc. . . . . Lexington.
In charge of Market Garden Field Station, Professor of Vegetable Gardening and Head of Department.
ANNA M. WALLACE, M.A. . . . . Inwood.
Curator, Department of Botany.
FRANK A. WAUGH, M.Sc. . . . . Campus.
Head of Division of Horticulture.
HARLAN N. WORTHLEY, B.Sc. . . . . 120 Pleasant Street.
Investigator in Entomology.

CONTROL SERVICE STAFF.

OLIVER S. FLINT, B.Sc. . . . . 18 Nutting Avenue.
Analyst.
HENRI D. HASKINS, B.Sc. . . . . Easthampton.
Official Chemist, Fertilizer Control.
MILDRED H. HOLLIS . . . . 17 Fearing Street.
Analyst.
JAMES T. HOWARD . . . . 7 Phillips Street.
Inspector.
FRANK J. KOKOSKI, B.Sc. . . . . Northampton Road.
Analyst.
JOHN J. SMITH . . . . 9 Phillips Street.
Collector of Blood Samples.
PHILIP H. SMITH, M.Sc. . . . . 102 Main Street.
Official Chemist, Feed Control.
RAYMOND W. SWIFT, B.Sc. . . . . North Amherst.
Analyst.
LEWELL S. WALKER, B.Sc. . . . . 19 Phillips Street.
Assistant Official Chemist, Fertilizer Control.

THE EXTENSION SERVICE STAFF.

KENYON L. BUTTERFIELD, A.M., LL.D. . . . . . . President's House.
President of the College.

JOHN D. WILLARD, B.A. . . . . 31 Lincoln Avenue.
Director.
JOHN B. ABBOTT, M.Sc. . . . . 21 Pleasant Street.
Extension Professor of Agronomy.
WILLIAM R. COLE . . . . 5 East Pleasant Street.
Assistant Extension Professor of Horticultural Manufactures.
GEORGE L. FARLEY, M.Sc. . . . . 61 Amity Street.
State Club Leader.

[1] Appointment effective November 15.

Clifford J. Fawcett, B.Sc. . . . . 7 Woodside Avenue.
Extension Professor of Animal Husbandry.
Robert D. Hawley, B.Sc. . . . . 5 Hitchcock Street.
Supervisor of Extension Schools and Exhibits.
William F. Howe . . . . North Amherst.
Assistant State Club Leader.
William P. B. Lockwood, M.Sc. . . . . West Newton.
Extension Professor of Dairying.
Louis M. Lyons, B.Sc. . . . . 10½ Kellogg Avenue.
Extension Editor and Supervisor of Correspondence Courses.
Allister F. MacDougall, B.Sc. . . . . 41 East Pleasant Street.
Extension Professor of Farm Management.
Robert J. McFall, Ph.D. . . . . 20 Spring Street.
Extension Professor of Agricultural Economics.
William C. Monahan, B.Sc. . . . . 34 Pleasant Street.
Extension Professor of Poultry Husbandry.
Dorothy W. Murdock . . . . 87 Pleasant Street.
Assistant State Club Leader.
Earle H. Nodine, B.Sc. . . . . 21 Pleasant Street.
Extension Instructor in charge of Poultry Club Work.
Sumner R. Parker, B.Sc. . . . . South Amherst.
Supervisor of County Agent Projects.
Lucy M. Queal, B.Sc. . . . . 8 Kellogg Avenue.
Assistant Professor of Home Economics.
Ralph W. Redman, B.Sc. . . . . 3 Hallock Street.
Assistant Director.
Lucile W. Reynolds, B.Sc. . . . . 87 Pleasant Street.
State Leader of Home Demonstration Agents.
Marion L. Tucker . . . . 46 Pleasant Street.
Assistant Extension Professor of Home Economics.
Ralph A. Van Meter, B.Sc. . . . . 7 East Pleasant Street.
Extension Professor of Pomology.
Joseph F. Whitney, B.Sc., M.L.A.[1] . . . . – –
Assistant Extension Professor of Landscape Gardening.

THE LIBRARY STAFF.

Henry S. Green, A.B., LL.D. . . . . Mount Pleasant.
Librarian.
Ethel A. Green, A.M. . . . . Mount Pleasant.
Library Assistant.
Lena V. Chapman . . . . 77 South Pleasant Street.
Assistant in charge of circulation.
Katharine Powell . . . . 9 Amity Street.
Department Librarian.
Bessie M. Weymouth . . . . 87 Pleasant Street.
Cataloguer.

OTHER OFFICERS.

John K. Broadfoot . . . . 130 Pleasant Street.
Cashier.
Thomas F. Butterworth . . . . 3 Phillips Street.
Engineer.
Grace Charman . . . . Infirmary.
Resident Nurse.
Lawrence S. Dickinson, B.Sc. . . . . 2 Fairview Way.
Superintendent of Grounds.
Lulu Diether . . . . Draper Hall.
Manager of the Dining Hall.
Anna M. Gabriel . . . . Infirmary.
Resident Nurse.
Samuel C. Hubbard . . . . North Amherst.
Foreman, Department of Floriculture.

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[1] On leave.

CLARENCE A. JEWETT	112 Pleasant Street.
Superintendent of Buildings.	
JOHN J. LEE	38 Cottage Street.
Assistant to the Military Detail.	
Mrs. MARIE MARSH	Abigail Adams House.
Matron.	
WILLIAM E. MARTIN	5 Phillips Street.
Laboratory Assistant, Department of Horticultural Manufactures.	
ENOS J. MONTAGUE, B.Sc.	Campus.
Farm Superintendent.	
ADELBERT SHEFFIELD	North Amherst.
Superintendent of Dairy Manufactures.	

GRADUATE ASSISTANTS.

MEHMED ALI, A.B.	14 North College.
Department of Agronomy.	
ELEANOR F. CHASE, B.Sc.	Abigail Adams House.
Department of Chemistry.	
NATHAN I. EPSTEIN, B.Sc.	9 Fearing Street.
Department of Chemistry.	
RENZY E. FLIKKEMA, A.B.	13 North College.
Department of Chemistry.	
JULIA P. HODGDON, B.A.	The Davenport.
Department of Microbiology.	
JOHN F. JOHNSON, B.Sc.	Poultry Plant.
Department of Poultry Husbandry.	
JOHN G. McCRIMMON, B.Sc. Agr.	84 Pleasant Street.
Department of Microbiology.	
RAYMOND A. MOONEY, B.Sc.	North Amherst.
Department of Agronomy.	
DAVID POTTER, B.Sc.	Clark Hall.
Department of Botany.	
J. RAYMOND SANBORN, B.Sc.	North Amherst.
Department of Microbiology.	
HARRISON M. TIETZ, B.Sc.	84 Pleasant Street.
Department of Entomology.	
HUBERT YOUNT, B.Sc. Agr.	9 Fearing Street.
Department of Agricultural Economics.	

STANDING COMMITTEES OF THE FACULTY.

1922–23.

COMMENCEMENT.

Dean LEWIS.
Treasurer KENNEY.
Secretary WATTS.
Mr. S. R. PARKER.
Professor THAYER.

COURSE OF STUDY.

President BUTTERFIELD.
Dean LEWIS.
Professor HART.
Professor WAUGH.
Professor PATTERSON.
Professor FERNALD.
Professor OSTRANDER.
Professor MARSHALL.
Professor CHAMBERLAIN.
Professor PHELAN.
Professor FOORD.

DISCIPLINE.

Dean LEWIS.
Professor MACHMER.
Professor PHELAN.
Professor CHENOWETH.
Professor HICKS.

EMPLOYMENT.

Professor JUDKINS.
Treasurer KENNEY.
Secretary WATTS.
Professor THAYER.

ACADEMIC ACTIVITIES BOARD.

Professor MACHMER.
Assistant Professor GOULD.

ENTRANCE EXAMINATIONS AND ADMISSION.

Professor HASBROUCK.
Professor PATTERSON.
Professor OSMUN.
Professor ASHLEY.
Professor MACHMER.

HEALTH AND SANITATION.

Professor MARSHALL.
Dean LEWIS.
Treasurer KENNEY.
Professor HICKS.
Miss SKINNER.

LIBRARY.

Professor MARSHALL.
Professor PATTERSON.
Professor CANCE.
Dr. GREEN.

SCHOLARSHIP.

Professor MACHMER.
Dean LEWIS.
Professor HASBROUCK.
Assistant Professor RAND.
Professor MACKIMMIE.
Professor PATTERSON.
Professor PARKER.
Professor HICKS.
Assistant Professor TORREY.

STUDENT LIFE.

Professor PATTERSON.
Secretary WATTS.
Professor PHELAN.
Professor SEARS.
Professor MACKIMMIE.
Professor THAYER.

ATHLETIC BOARD.

Dean LEWIS.
Professor HASBROUCK.
Professor OSMUN.

The College

Admission.

A. Application for Admission.

Correspondence concerning admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of character, which, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege at least one month before the date of the examination. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. Modes of Admission.

Students are admitted to the freshman class either upon certificate or upon examination. No *diploma* from a secondary school will be accepted.

Certificates. — Certificates will be received from those schools in New England which have been approved by the New England College Entrance Certificate Board. Principals of schools in New England who desire the certificate privilege should address the secretary of the Board, Professor Frank W. Nicolson, Wesleyan University, Middletown, Conn. Certificates from schools outside of New England may be received if those schools are on the approved list of the leading colleges of the section in which the school in question is located.

The credentials of the Board of Regents of the State of New York are accepted as satisfying the entrance requirements of this college when offered subject for subject.

Certificates in order to be accepted must present in the prescribed and restrictive elective groups at least three of the necessary fourteen and one-half credits. It is to be understood, however, that responsibility for certification in either elementary French, elementary German, English 1 or English 2, Latin A, Greek A or algebra must be assumed by one school, if the candidate has received his preparation in any one subject named above in more than one school. Subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

Examinations. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.

Entrance examination for admission to the Massachusetts Agricultural College will be held at the following centers: —

In June	Amherst, Department of Physics building. Massachusetts Institute of Technology, Cambridge, Mass. Worcester, Horticultural Hall.
In September	Amherst, Department of Physics building.

Please note that September examinations are held in Amherst only.

Schedule for Entrance Examinations, June 14–16, inclusive, 1923. — The examinations in June will follow this schedule: —

First Day.

7.45 A.M.	Registration.[1]
8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
1.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.

Second Day.

8.00 A.M.	English 1 and 2.
11.00 A.M.	Algebra.
2.00 P.M.	History (ancient; medieval and modern; English; general; United States and civics).

Third Day.

8.00 A.M.	French, German, Spanish, required and elective.
1.00 P.M.	Latin, elementary, intermediate and advanced, and all one-half credit electives, except those already noted.

Schedule for Entrance Examinations in September. — In September, 1923, the examinations will be given September 19–22, inclusive, and will follow the order indicated below: —

First Day.

1.00 P.M.	Registration.[1]
1.15–5.00 P.M.	Greek, elementary and intermediate.

Second Day.

8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.

Third Day.

8.00 A.M.	English 1 and 2.
11.00 A.M.	Algebra.
2.00 P.M.	History (ancient; medieval and modern; English; general; United States and civics).

[1] Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

Fourth Day.

8.00 A.M. French, German, Spanish, required and elective.
1.00 P.M. Latin, elementary, intermediate and advanced, and all one-half credit electives, except those already noted.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-year high school course, or its equivalent, and are stated in terms of units. The term unit means the equivalent of at least four recitations a week for a school year.

Fourteen and one-half units must be offered for admission in accordance with the entrance requirements as stated below. Entrance credits gained either by certificate or by examination will hold good for one year.

Entrance Requirements.

1. *Prescribed.* — The following units are prescribed: —

English 1	1½
English 2	1½
A foreign language	2
Algebra	1½
Plane geometry	1
	7½

2. *Restricted Electives.* — Three units to be selected from —

Science	1, 2 or 3
History (American history and civics included)	1, 2 or 3
A second foreign language	2 or 3
Additional work in first foreign language	1 or 2

3. *Free Margin.* — Free margin of four units to consist of any substantial work (including agriculture,[1] general science and a fourth year of English) for which credit of not less than one-half unit earned in one year is given toward a secondary school diploma.

Units presented in the free margin group are not to be offered by examination or by certificate, but presented by submitting a principal's statement to the effect that such units have been earned in a secondary school, and have been credited toward a diploma issued by such a school.

4. One unit of history must be offered in either the restricted electives or the free margin.

5. If elementary algebra and plane geometry are counted as three units, the total requirement will be fifteen units.

6. Both the credits under the prescribed group and the restricted elective group must be presented either by certificate from an approved school or by examination, or by a combination of both.

The following is a list of subjects in which the entrance credits must be offered in the prescribed and restricted elective groups: —

[1] See page 30 for details.

Mathematics and Science.

Botany[1]	½ or 1
Chemistry[1]	1
Algebra	1½
Plane geometry	1
Solid geometry	½
Trigonometry	½
Physics[1]	1
Geology	½
Physical geography	½
Physiology	½
Zoölogy[1]	½

History.

Ancient	1
Medieval and modern	1
English	1
General	1
United States and civics	1

English.

English 1	1½
English 2	1½

Foreign Language.

Elementary French	2
Elementary German	2
Elementary Spanish	2
Elementary Latin	2
Elementary Greek[2]	2
Intermediate French	1
Intermediate German	1
Intermediate Spanish	1
Intermediate Latin	1
Intermediate Greek[2]	1
Advanced French	1
Advanced German	1
Advanced Spanish	1
Advanced Latin	1

No applicant deficient in both algebra and plane geometry will be admitted.

PRESENTATION OF NOTE-BOOKS. — The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 1, below).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificates should not present note-books; but their certificates must state that note-books have been satisfactorily completed.

D. Statement of Preparation Required for Admission.

Agriculture. — Entrance credit in agriculture is granted on the following basis: —

I. The Massachusetts Agricultural College accepts a maximum of four credits in agriculture from any secondary or county agricultural high school in Massachusetts offering work in that subject, provided evidence of such work having been done is submitted on a principal's statement, as is indicated in the "free margin" group.

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[1] Note-book required as part of the preparation will be credited as part of the examination.

[2] Examination in September only.

II. In high schools organizing agricultural club work under the supervision and rules of the junior extension service of the college, one credit is granted for each full year of work performed under the following plan: —

Work of the Winter Term. — (*a*) The study of textbooks such as are suitable for secondary school instruction in agriculture.

(*b*) Course of Study: A general outline of suggested topics for study.

(*c*) Visits by a representative of the Massachusetts Agricultural College for observation, counsel and advice in regard to kind and amount of work being done in agriculture.

(*d*) Formation of an agricultural club with officers from among its own members, meeting once a month under local supervision of some one authorized to act for the school authorities.

Work of the Spring Term. — Same in general form as winter term.

Work of the Summer Term. — An approved project conforming to the rules of some one or more of the agricultural clubs of the junior extension service of the Massachusetts Agricultural College.

Work of the Fall Term. — (*a*) An exhibit of work.

(*b*) Reports and story of achievement submitted to the junior extension service of the college.

The maximum number of credits in agriculture is four.

Botany. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary textbook study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Stevens' "Introduction to Botany" and Bergen & Davis' "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit, and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

Chemistry. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from any standard textbook, with laboratory work on the properties of the common elements and their simpler compounds. No particular work is prescribed. The keeping of a note-book is required.

Students who do not take chemistry in the preparatory school begin the subject in college, and are required to do extra work during the first two terms, as outlined under chemistry, courses 1 and 2, page 92.

Mathematics. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of

linear or quadratic equations; problems depending upon quadratic equations; the binomial theorem for positive integral exponents, the formulas for the *n*th term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good textbooks, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good textbooks, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

Physics. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work must consist of both class-room work and laboratory practice. The work covered in the class-room should be equal to that outlined in Hall & Bergen's "Textbook of Physics" or Millikan & Gale; the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

Physiology. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body; Briefer Course."

Zoölogy, Physical Geography, Geology. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis' "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, textbooks entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Textbook in General Zoölogy." For geology, A. P. Brigham's "A Textbook of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present note-books, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

History. — The required unit must be offered in either ancient history, medieval and modern history, English history, general history, or United

States history and civics. Either one, two or three elective units in any of the historical subjects here named may be offered, provided that no unit be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good textbooks, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on outline maps.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers, in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

English. — The study of English in school has two main objects, which should be considered of equal importance: (1) command of correct and clear English, spoken and written; (2) ability to read with accuracy, intelligence and appreciation, and the development of the habit of reading good literature with enjoyment.

(1) *Grammar and Composition* (One and One-half Units). — The first object requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, sentences and paragraphs should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise letter-writing, narration, description and easy exposition and argument. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

(2) *Literature* (One and One-half Units). — The second object is sought by means of two lists of books, headed, respectively, "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud and encouraged to commit to memory some of the more notable passages both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads and with their place in literary history.

A. *Books for Reading*. — The aim of this course is to foster in the student the habit of intelligent reading and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

The books provided for reading are arranged in the following groups, from each of which at least two selections are to be made, except that for any book in Group I a book from any other may be substituted.

GROUP I. CLASSICS IN TRANSLATION.

The "Old Testament," at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther.

The "Odyssey," with the omission, if desired, of Books I–V, XV and XVI.

The "Æneid."

The "Odyssey" and the "Æneid" should be read in English translations of recognized literary excellence.

GROUP II. DRAMA.

Shakespeare: "Merchant of Venice," "As You Like It," "Julius Cæsar."

GROUP III. PROSE FICTION.

Dickens: "A Tale of Two Cities."
George Eliot: "Silas Marner."
Scott: "Quentin Durward."
Hawthorne: "The House of the Seven Gables."

GROUP IV. ESSAYS, BIOGRAPHY, ETC.

Addison and Steele: "The Sir Roger de Coverley Papers."
Irving: "The Sketch Book," selections covering about 175 pages.
Macaulay: "Lord Clive."
Parkman: "The Oregon Trail."

GROUP V. POETRY.

Tennyson: "The Coming of Arthur," "Gareth and Lynette," "Lancelot and Elaine," "The Passing of Arthur."

Browning: "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Herve Riel," "Pheidippides," "My Last Duchess," "Up at a Villa — Down in the City," "The Italian in England," "The Patriot," "The Pied Piper," "De Gustibus," "Instans Tyrannus."

Scott: "The Lady of the Lake."
Coleridge: "The Ancient Mariner."
Arnold: "Sohrab and Rustum."

B. Books for Study. — This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. The books provided for study are arranged in four groups, from each of which one selection is to be made.

The books provided for study are arranged in four groups, from each of which one selection is to be made.

GROUP I. DRAMA.

Shakespeare: "Macbeth," "Hamlet."

GROUP II. POETRY.

Milton: "L'Allegro," "Il Penseroso," "Comus."

Book IV of Palgrave's "Golden Treasury" (first series), with special attention to Wordsworth, Keats and Shelley.

Group III. Oratory.

Burke: "Speech on Conciliation with America."
Washington's "Farewell Address," Webster's "First Bunker Hill Oration," and Lincoln's "Gettysburg Address."

Group IV. Essays.

Macaulay: "Life of Johnson."
Carlyle: "Essay on Burns," with a brief selection from Burns' poems.

Examination. — However accurate in subject-matter, no paper will be considered satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which will be on grammar and composition, and the other on literature.

In grammar and composition, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors. The main test in composition will consist of one or more essays, developing a theme through several paragraphs; the subjects will be drawn from the books read, from the candidate's other studies and from his personal knowledge and experience quite apart from reading.

The examination in literature will include: —

(*a*) General questions designed to test such a knowledge and appreciation of literature as may be gained by fulfilling the requirements defined under "A, Reading," above.

(*b*) A test on the books prescribed for study, which will consist of questions upon their content and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their works and the periods of literary history to which they belong.

French. — Elementary: The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a third credit unit in French as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in French will be given unless the candidate has presented elementary French on certificate, or has written the examination in elementary French.

No examination for a fourth credit in French will be given unless the candidate has presented both elementary and intermediate French upon certificate, or has written the examination in both elementary and intermediate French.

German. — Elementary: The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).

Third and fourth year German (elective subjects for admission). — For a third credit unit in German as an elective subject for entrance, when required units have been offered in German, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in German will be given unless the candidate has presented elementary German upon certificate, or has written the examination in elementary German.

No examination for a fourth credit in German will be given unless the candidate has presented both elementary and intermediate German upon certificate, or has written the examination for both elementary and intermediate German.

Spanish. — Elementary: The necessary preparation for this examination is stated in the description of the two-year course in elementary Spanish recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year Spanish (elective subjects for admission). — For a third credit unit in Spanish as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in Spanish will be given unless the candidate has presented elementary Spanish on certificate, or has written the examination in elementary Spanish.

No examination for a fourth credit in Spanish will be given unless the candidate has presented both elementary and intermediate Spanish upon certificate, or has written the examination in both elementary and intermediate Spanish.

Greek. — *Elementary.* — Greek grammar and composition: Translation into Greek of short sentences illustrating common principles of syntax.

The examination in grammar and prose composition will be based on the first four books of Xenophon's "Anabasis."

Intermediate. — Homer's "Iliad," Books I and II (omitting Book II, 494 to end), and the Homeric forms, constructions, idioms and prosody.

Prose composition, consisting of continuous prose based on Xenophon, and other Attic prose of similar difficulty.

Translation of passages of Homer at sight.

The examinations in Greek, elementary and intermediate, will be given in September only.

Latin. — *Elementary.* — Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

Intermediate. — Cicero (third oration "Against Catiline" and the orations "For Archias" and "For Marcellus") and sight translation of prose.

Advanced. — Vergil (Æneid, II, III and VI) and sight translation of poetry.

E. Admission to Advanced Standing.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this require-

ment, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.
5. A statement from the proper officer, giving the total number of credits required for graduation by the institution from which the applicant is transferring, and, of this total, the number that the applicant has satisfactorily completed at the time of transfer.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. Other Information about Entrance.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)
2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.
3. To matriculate, candidates must offer twelve and one-half of the fourteen and one-half units required for admission, and will be conditioned in those subjects not passed. At least five and one-half credits must be in the prescribed group. No candidate deficient in both algebra and plane geometry will be admitted.
4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination during the first week of the second term. (2) Second entrance condition examination before the beginning of the period of final examinations of the second term, upon the payment of a fee of $5 to the treasurer.
5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.
6. Examinations in part of the subjects required for entrance may be taken one year before entering college.
7. For information concerning expenses, scholarships, etc., see "General Information."
8. For information concerning admission to short courses, see "Short Courses."
9. Application for admission as a "Special Student" should be made to the Dean.

Courses of Instruction.

TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.

[The figures indicate the number of credit hours per week. Freshman credit is computed on the basis of total clock hours per week spent in class room and study. For details, see the description of the courses.]

Freshman Year.

First Term.

All work required.

Subject.	Courses and Numbers.	Credit in Clock Hours per Week.
Agriculture	Agronomy 1	6
Algebra	Mathematics 1	12
Chemistry	Chemistry 1 or 4	12 or 9
English	English 1	6
Language	French or German 1 or 4	9
Military (for men)	Military 1	3
Recreation (military substitute for women).	Physical Education 4	3
Physical Education (military substitute for men).	Physical Education 7	3
Hygiene (for men)	Physical Education 1	1
Recreation (for men)	Physical Education 2	1
Rural Home Life (for women)	Rural Home Life 1	2
Total credits (clock hours per week).		47 or 50

College life (attendance without credit).

Second Term.

Agriculture	Agriculture 2	6
Algebra	Mathematics 2	6
or Solid Geometry	Mathematics 3	6
Mensuration	Mathematics 4	6
Chemistry	Chemistry 2 or 5	15 or 9
English	English 2	6
Language	French or German 2 or 5	9

FRESHMAN YEAR — *Concluded.*

Second Term — Concluded.

SUBJECT.	Courses and Numbers.	Credit in Clock Hours per Week.
Military (for men)	Military 2	3
Recreation (military substitute for women).	Physical Education 5	3
Physical Education (military substitute for men).	Physical Education 8	3
Total credits (clock hours per week).		45 or 51

College life (attendance without credit).

Third Term.

Agriculture	Agriculture 3	12
Trigonometry	Mathematics 5	9
Botany	Botany 3	9
English	English 3	6
Language	French or German 3 or 6	6
Military (for men)	Military 3	3
Recreation (military substitute for women).	Physical Education 6	4
Physical Education (military substitute for men).	Physical Education 9	3
Recreation (for men)	Physical Education 3	1
Total credits (clock hours per week).		46

Sophomore Year.

First Term.

Subject.	Course Number.	Class Hours.	Laboratory Hours.	Credit Hours per Week.
Required.				
Botany	25	1	4	3
English	25	2	–	2
Physics	25	3	2	4
Zoölogy	25	2	4	4
Military (for men)	25	3	–	3
Microbiology (military substitute for men and women).	25	2	–	2
Physical Education (military substitute for men).	30	–	2	1
Physical Education (military substitute for women).	27	–	3	1
Physical Education (for men)	25	–	1	–[1]
Total required	–	–	–	16
Elective.				
Animal Husbandry	25	2	2	3
Chemistry	25	1	4	3
Drawing	25	–	6	3
French	25 or 28	3	–	3
German	25 or 28	3	–	3
Rural Engineering	25	–	4	2
Rural Home Life (for women)	25	1	4	3

Minimum credit for first term, 18.
Maximum credit for first term, 22.

[1] Credit given in spring term.

SOPHOMORE YEAR — *Continued.*

Second Term.

SUBJECT.	Course Number.	Class Hours.	Laboratory Hours.	Credit Hours per Week.
Required.				
Agricultural Economics	26	5	–	5
English	26	2	–	2
Physics	26	3	2	4
Military (for men)	26	3	–	3
Microbiology (military substitute for men)	26	2	–	2
Physical Education (military substitute for men).	31	–	2	1
Agricultural Education (military substitute for women).	26	2	–	2
Physical Education (military substitute for women).	28	–	3	1
Total required	–	–	–	14
Elective.				
Animal Husbandry	26	2	2	3
Botany	26	1	4	3
Chemistry	26	1	4	3
Drawing	26	–	6	3
Economic Sociology	26	5	–	5
Entomology	26	3	–	3
French	26 or 29	3	–	3
German	26 or 29	3	–	3
Mathematics	26	2	–	2
Rural Home Life (for women)	26	1	4	3
Zoölogy	26	1	4	3

Minimum credit for second term, 18.
Maximum credit for second term, 22.

SOPHOMORE YEAR — *Concluded.*

Third Term.

SUBJECT.	Course Number.	Class Hours.	Laboratory Hours.	Credit Hours per Week.
Required.				
Agronomy	27	4	2	5
English	27	2	–	2
Rural Sociology	27	3	–	3
Military (for men)	27	3	–	3
Microbiology (military substitute for men and women).	27	2	–	2
Physical Education (military substitute for men).	32	–	2	1
Physical Education (military substitute for women).	29	–	3	1
Physical Education (for men)	26	–	1	1[1]
Total required	–	–	–	13 or 14
Elective.				
Botany	27	1	4	3
Chemistry	27	1	8	5
Chemistry	30	3	4	5
Drawing	27	–	6	3
Entomology	27	2	–	2
Entomology	28	–	4	2
French	27 or 30	3	–	3
Geology	27	3	4	5
German	27 or 30	3	–	3
Horticulture	27	2	2	3
Mathematics	27	–	6	3
Physics	27	3	2	4
Rural Engineering	26	–	4	2
Rural Home Life (for women)	27	1	4	3

Minimum credit for third term, 18.
Maximum credit for third term, 22.

[1] Credit for Physical Education 25 and 26 given in third term.

MAJORS: JUNIOR AND SENIOR YEARS.

General Statement.

A major consists of 45 credit hours of correlated work, which is arranged by the student and his adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their departments. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules governing Majors.

Rule 1. *Election.* — Each student, before the first term of his junior year, shall elect a major subject from the list of majors given below; and this major shall consist of 45 credit hours of correlated work.

Rule 2. *Minimum Credits.* — The minimum number of credits for graduation shall be 237 credit hours, inclusive of military drill and physical education.

Rule 3. *Maximum Credits.* — The maximum number of credits for any term of the junior or senior year shall be 22; the minimum shall be 19.

Rule 4. *Humanities and Rural Social Science.* — A minimum of 18 credit hours in the Divisions of the Humanities and Rural Social Science will be required of all students during their junior and senior years, with the following restriction: that a minimum of 5 credit hours will be required in each of the divisions.

Rule 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student elects his major. The adviser has full authority to prescribe the student's work up to 45 hours. He will, however, so far as practicable, recognize the individual needs of the student. It is also expected that students will seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.* — Each student during his junior and senior years is required to take 45 hours in his major and also 18 hours in the Divisions of the Humanities and Rural Social Science, making a total of 63 hours (but see Rule 4). He is allowed free choice of courses to complete his required hours.

Rule 7. *Registration.* — No junior or senior shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the Schedule Room five weeks before the close of each term.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the succeeding term and countersign the card.

(3) Each course card must be filled out, giving the name of student, his major, his class and the name and address of parent or guardian. When the major courses have been entered on this card, and the hours of free elections added by the student, the card, accompanied by one hour plan, must be returned to the Schedule Room two weeks before the beginning of the final examination period.

RULE 8. *Change of Major.* — Applications for change of major may be made to the dean in writing at any time; when approved by both major advisers concerned and by the dean and the committee on scholarship, they become operative at the beginning of the term following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

AGRONOMY. (Major.)

Professor ARTHUR B. BEAUMONT, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.
Agronomy	50 **I.**	5
Agronomy	51 **III.**	3
Agronomy	75 **I.**	5
Agronomy	77 **II.**	5
Animal Husbandry	50 **I.**	3
Chemistry	51 **I.**	8
Chemistry	52 **II.**	8
Farm Management	76 **I.**	3
Farm Management	77 **III.**	3
		43

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25	3	Agronomy 50	5	Agronomy 75	5
	German 25 or 28	3	Chemistry 51	8	Farm Management 76	3
			Animal Husbandry 50	3		
II.	Botany 26	3	Chemistry 52	8	Agronomy 77	5
	Chemistry 26	3				
	German 26 or 29	3				
	Mathematics 26	2				
III.	German 27 or 30	3	Agronomy 51	3	Farm Management 77	3
	Mathematics 27	3				
	Geology 27	5				
IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Chemistry 25 and 26, German 25 or 28, 26 or 29, 27 or 30, Geology 27, Botany 26.
ADVISED. — Mathematics 26 and 27.

Animal Husbandry. (Major.)

Professor S. M. Salisbury, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agronomy	50 **I.**	5
Animal Husbandry	50 **I.**	3
Animal Husbandry	51 **II.**	3
Animal Husbandry	52 **III.**	3
Animal Husbandry	53 **III.**	3
Animal Husbandry	75 **I.**	3
Animal Husbandry	78 **II.**	3
Animal Husbandry	79 **III.**	3
Animal Husbandry	81 **II.**	1
Animal Husbandry	82 **III.**	1
Dairying	50 **I.**	5
Farm Management	75 **II.**	3
Farm Management	76 **I.**	3
Veterinary	50 **II.**	5
		44

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Animal Husbandry 25	3	Animal Husbandry 50	3	Animal Husbandry 75	3
			Agronomy 50	5	Farm Management 76	3
			Dairying 50	5		
II.	Animal Husbandry 26	3	Animal Husbandry 51	3	Animal Husbandry 78	3
			Veterinary 50	5	Animal Husbandry 81	1
					Farm Management 75	3
III.	Chemistry 30	5	Animal Husbandry 52	3	Animal Husbandry 79	3
			Animal Husbandry 53	3	Animal Husbandry 82	1
IV.						

Sophomore Elective Prerequisites (Required). — Animal Husbandry 25 and 26, Chemistry 30.

Additional Information. — The balance of the sophomore electives allowed are left to the student to choose.

DAIRYING. (Major.)

Professor HENRY F. JUDKINS, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agricultural Economics	53 **III.**	5
Animal Husbandry	50 **I.**	3
Animal Husbandry	81 **II.**	1
Animal Husbandry	82 **III.**	1
Chemistry	76 **I.**	5
Dairying	50 **I.**	5
Dairying	52 **II.**	1
Dairying	51 **III.**	5
Dairying	75 **II.**	5
Dairying	76 **III.**	5
Farm Management	75 **I.**	3
Microbiology	50 **I.**	5
Microbiology	51 **II.**	5
Microbiology	82 **I.**	5
Rural Engineering	52 **III.**	5
		59

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Animal Husbandry 25	3	Dairying 50	5	Chemistry 76	5
	Chemistry 25	3	Microbiology 50	5	Microbiology 82	5
	Rural Engineering 25	2	Animal Husbandry 50	3		
II.	Animal Husbandry 26	3	Dairying 52	1	Animal Husbandry 81	1
			Microbiology 51	5	Dairying 75	5
					Farm Management 75	3
III.	Chemistry 27	3	Chemistry 30	5	Agricultural Economics 53	5
	Rural Engineering 26	2	Dairying 51	5	Animal Husbandry 82	1
			Rural Engineering 52	5	Dairying 76	5
IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Animal Husbandry 25 and 26, Rural Engineering 25 and 26, Chemistry 25, 27.
ADDITIONAL INFORMATION. — The balance of the sophomore electives allowed are left to the student to choose.

Farm Management. (Major.)

Professor James A. Foord, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agronomy	50 **I.**	5
Animal Husbandry	50 **I.**	3
Animal Husbandry	51 **II.**	3
Animal Husbandry	53 **III.**	3
Dairying or	50 **I.**	5
Dairying	77 **III.**	5
Farm Management	75 **II.**	3
Farm Management	76 **I.**	3
Farm Management	77 **III.**	3
Farm Management	78 **II.**	1
Farm Management	79 **III.**	1
Microbiology or	50 **II.**	
Microbiology	50 **III.**	5
Rural Engineering	75 **I.**	4
Rural Engineering	78 **III.**	5
Rural Engineering	79 **III.**	5
		49

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Animal Husbandry 25	3	Agronomy 50	5	Rural Engineering 75	4
	Rural Engineering 25	2	Dairying 50 (or 77 **III**)	5	Farm Management 76	3
			Animal Husbandry 50	3		
II.	Animal Husbandry 26	3	Animal Husbandry 51	3	Farm Management 75	3
			Microbiology 50	5	Farm Management 78	1
					Rural Engineering 78	5
III.	Chemistry 30	5	Microbiology 50	5	Farm Management 77	3
	Horticulture 27	3	Animal Husbandry 53	3	Farm Management 79	1
	Rural Engineering 26	2	Dairying 77	5	Rural Engineering 79	5
IV.						

Sophomore Elective Prerequisites (Required). — Animal Husbandry 25 and 26, Rural Engineering (shop work) 25 and 26, Chemistry 30, and Horticulture 27.

Additional Information. — Botany 26, Drawing 26, Entomology 26 and 27, Dairying 51, Pomology 50, 51, 76 and 78, and Veterinary 75, 76 and 78 are suggested as additional courses for the student fitting himself for general agriculture.

Poultry Husbandry. (Major.)

Professor John C. Graham, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agricultural Economics	53 **III.**	5
Agronomy	50 **I.**	5
Animal Husbandry	50 **I.**	3
Farm Management	75 **II.**	3
Poultry Husbandry	50 **I.**	5
Poultry Husbandry	51 **II.**	3
Poultry Husbandry	52 **III.**	5
Poultry Husbandry	75 **I.**	5
Poultry Husbandry	76 **I.**	4
Poultry Husbandry	77 **II.**	5
Poultry Husbandry	79 **III.**	4
Veterinary Science	85 **I.**	3
Veterinary Science	86 **II.**	3
Veterinary Science	87 **III.**	3
		56

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.			Agronomy 50	5	Poultry 75	5
			Animal Husbandry 50	3	Poultry 76	4
			Poultry 50	5	Veterinary 85	3
II.			Poultry 51	3	Farm Management 75	3
					Poultry 77	5
					Veterinary 86	3
III.			Agricultural Economics 53	5	Poultry 79	4
			Poultry 52	5	Veterinary 87	3
IV.						

Sophomore Recommendations. — Students intending to major in Poultry Husbandry are urged to take Zoölogy 26, Rural Engineering 25, 26.
Strongly Advised. — Microbiology 50 I, Rural Engineering 52 III, Zoölogy 76 II.

Floriculture.

Professor Clark L. Thayer, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Botany	50 **I.**	2
Botany	51 **II.**	2
Floriculture	50 **I.**	4
Floriculture	51 **II.**	4
Floriculture	52 **III.**	4
Floriculture	53 **I.**	4
Floriculture	55 **III.**	3
Floriculture	75 **I.**	3
Floriculture	76 **II.**	3
Floriculture	77 **III.**	3
Floriculture	79 **II.**	3
Floriculture	80 **III.**	3
Horticulture	50 **I.**	5
Horticulture	51 **III.**	5
		48

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Drawing 25	3	Floriculture 50	4	Floriculture 75	3
			Floriculture 53	4	Horticulture 50	5
			Botany 50	2		
II.	Drawing 26	3	Floriculture 51	4	Floriculture 76	3
	Entomology 26	3	Botany 51	2	Floriculture 79	3
	Mathematics 26	2				
III.	Entomology 27	2	Floriculture 52	4	Floriculture 77	3
	Horticulture 27	3	Floriculture 55	3	Floriculture 80	3
	Mathematics 27	3			Horticulture 51	5
IV.						

Sophomore Elective Prerequisites. — Drawing 25, 26 and 27, Entomology 26 and 27, Botany 26 and Horticulture 27; Mathematics 26, 27 for students who wish to elect courses in Landscape Gardening.

Additional Information. — Substitutions in sophomore prerequisites may be made in conference with the adviser.

Advised. — The department advises all students who major in this subject to take Entomology 50 and Landscape Gardening 75.

Landscape Gardening. (Major.)

Professor Frank A. Waugh, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Floriculture	78 **III.**	3
Horticulture	50 **I.**	5
Horticulture	51 **III.**	5
Landscape Gardening	50 **I.**	5
Landscape Gardening	51 **II.**	4
Landscape Gardening	52 **III.**	5
Landscape Gardening	75 **I.**	3
Landscape Gardening	76 **I.**	4
Landscape Gardening	77 **III.**	4
Landscape Gardening or	78 **II.**	3
Landscape Gardening	79 **II.**	3
Landscape Gardening	80 **I.**	4
Landscape Gardening	81 **II.**	4
Landscape Gardening	82 **III.**	4
		56

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Drawing 25	3	Landscape Gardening 50	5	Landscape Gardening 75	3
			Horticulture 50	5	Landscape Gardening 76	4
					Landscape Gardening 80	4
II.	Drawing 26	3	Landscape Gardening 51	4	Landscape Gardening 78 or 79	3
	Mathematics 26	2	Landscape Gardening 78 or 79	3	Landscape Gardening 81	4
	Entomology 26	3				
III.	Drawing 27	3	Landscape Gardening 52	5	Landscape Gardening 77	4
	Mathematics 27	3	Horticulture 51	5	Landscape Gardening 82	4
	Horticulture 27	3	Floriculture 55	3		
IV.						

Sophomore Elective Prerequisites (Required). — Drawing 25, 26 and 27, Mathematics 26 and 27, Horticulture 27.

Additional Information. — Modifications may be permitted when they appear advisable.

POMOLOGY. (Major.)

Professor FRED C. SEARS, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.
Agricultural Economics	53 **III.**	5
Agronomy	77 **II.**	5
Botany	50 **I.**	1–4
Horticultural Manufactures	75 **I.**	5
Horticultural Manufactures	76 **II.**	3
Pomology	50 **I.**	3
Pomology	51 **II.**	3
Pomology	52 **III.**	3
Pomology	54 **II.**	3
Pomology	75 **I.**	3
Pomology	76 **II.**	3
Pomology	77 **I.**	3
Pomology	78 **III.**	3
Pomology	80 **I.**	1
Pomology	81 **II.**	1
Pomology	82 **III.**	1
Rural Engineering	78 **III.**	5
		51–54

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.			Botany 50	1–4	Horticultural Manuf. 75	5
			Pomology 50	3	Pomology 75	3
					Pomology 77	3
					Pomology 80	1
II.			Pomology 51	3	Agronomy 77	5
			Pomology 54	3	Horticultural Manuf. 76	3
					Pomology 76	3
					Pomology 81	1
III.	Horticulture 27	3	Pomology 52	3	Pomology 78	3
			Agricultural Economics 53	5	Pomology 82	1
					Rural Engineering 78	5
IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Horticulture 27.

ADVISED. — Rural Engineering 26, Entomology 26 and 27.

[illegible] — The rest of the sophomore electives allowed are left to the student to choose.

Vegetable Gardening. (Major.)

Assistant Professor Roy D. Harris, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agronomy	75 **I.**	5
Agronomy	77 **II.**	5
Botany	50 **I.**	2
Botany	51 **II.**	2
Vegetable Gardening	52 **II.**	5
Vegetable Gardening	53 **III.**	5
Vegetable Gardening	75 **I.**	5
Vegetable Gardening	76 **II.**	5
Vegetable Gardening	77 **III.**	5
		39

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.			Agronomy 75	5	Vegetable Gardening 75	5
			Botany 50	2		
II.	Botany 26	3	Agronomy 77	5	Vegetable Gardening 76	5
			Botany 51	2		
			Vegetable Gardening 52	5		
III.	Horticulture 27	3	Vegetable Gardening 53	5	Vegetable Gardening 77	5
IV.						

Sophomore Elective Prerequisites (Required). — Botany 26, Horticulture 27.

Advised. — Rural Engineering 26, Entomology 26 and 27.

Additional Information. — The rest of the sophomore electives allowed are left to the student to choose.

Economic Botany. (Major.)

Professor A. Vincent Osmun, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Botany	52 **I.**	3
Botany	53 **II.**	3
Botany	54 **III.**	3
Botany	55 **I.**	3
Botany	56 **II.**	3
Botany	75 **I.**	5
Botany	76 **II.**	5
Botany	77 **III.**	5
Botany	78 **I.**	5
Botany	79 **II.**	5
Botany	80 **III.**	5
Botany	82 **II.**	3
Botany	83 **III.**	3
Botany	86 **I.**	1
Botany	87 **II.**	1
Botany	88 **III.**	1
Chemistry	51 **I.**	8
		62

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25	3	Botany 52	3	Botany 75	5
	German 25 or 28	3	Botany 55	3	Botany 78	5
			Chemistry 51	8	Botany 86	1
II.	Chemistry 26	3	Botany 53	3	Botany 76	5
	German 26 or 29	3	Botany 56	3	Botany 79	5
	Botany 26	3			Botany 82	3
					Botany 87	1
III.	German 27 or 30	3	Botany 54	3	Botany 77	5
	Botany 27[1]	3			Botany 80	5
					Botany 83	3
					Botany 88	1
IV.						

Sophomore Elective Prerequisites (Required). — German 25 or 28, 26 or 29, 27 or 30, Botany 26.
Advised. — Chemistry 25 and 26.
Additional Information. — The balance of the sophomore electives allowed are left to the student to choose.
Selection of 45 credits of the above (Pathology 75, 76 and 77, Physiology 78, 79 and 80).

[1] May be taken in junior or senior year.

Agricultural Chemistry. (Major.)

Professor Charles A. Peters, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Chemistry	51 **I.**	8
Chemistry	52 **II.**	8
Chemistry	62 **III.**	5
Chemistry	65 **III.**	5
Chemistry	76 **I.**	5
Chemistry	77 **II.**	5
Chemistry	80 **I.**	5
Chemistry	86 **II.**	3
Chemistry	87 **III.**	3
Chemistry	92 **II.**	3[1] (92, 94)
Chemistry	94 **II.**	
Chemistry	91 **III.**	
Chemistry	93 **II.**	5 (91, 93, 95)
Chemistry	95 **III.**	
		50[2]

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25	3	Chemistry 51	8	Chemistry 76	5
					Chemistry 80	5
II.	Chemistry 26	3	Chemistry 52	8	Chemistry 77	3
					Chemistry 86	3
					Chemistry 92, 94	3
III.	Chemistry 27	5	Chemistry 62	5	Chemistry 87	3
			Chemistry 65	5	Chemistry 91, 93, 95	5
IV.						

Sophomore Elective Prerequisites (Required). — Chemistry 25, 26 and 27.

Advised. — German 25 or 28, 26 or 29, 27 or 30, Physics 27.

Additional Information. — The balance of the sophomore electives allowed are left for the student to choose.

[1] Courses 92, 94 may be changed from 3 credits to an option of 3 or 5 credits. Students will select one course from groups 92, 94, and 91, 93, 95 respectively.

[2] Only 45 credits required.

Economic Entomology. (Major.)

Professor Henry T. Fernald, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Botany or	50 **I.**	3
Botany	52 **I.**	3
Entomology	50 **I.**	3
Entomology	52 **II.**	3
Entomology	53 **I.**	5
Entomology	54 **I.**	3
Entomology	55 **III.**	3
Entomology	75 **III.**	4
Entomology	76 **I.**	5
Entomology	77 **II.**	3
Entomology	78 **III.**	4
Entomology	90 **II.**	3
Zoölogy or	50 **I.**	3
Zoölogy or	54 **II.**	3
Chemistry	51 **I.**	8
		42 or 47

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	French 25 or 28 or German 25 or 28	3	Entomology 54	3	Entomology 76	5
	Chemistry 25	3	Entomology 53	5	Entomology 85	3
			Botany 50 or 52	3	Horticulture 50	5
			Zoölogy 50	3		
			or Chemistry 51	8		
II.	French 26 or 29 or German 26 or 29	3	Entomology 52	3	Entomology 77	3
	Entomology 26	3	Entomology 56	3	Entomology 90	3
	Botany 26	3	Microbiology 50	5		
III.	French 27 or 30 or German 27 or 30	3	Entomology 55	3	Entomology 78	4
	Entomology 27	2	Entomology 75	4	Horticulture 51	5
	Horticulture 27	3	Entomology 65	5	Pomology 78	3
			Pomology 79	3		
			Vegetable Gardening 50	3		
IV.						

Sophomore Elective Prerequisites (Required). — Entomology 26 and 27, Botany 26, Horticulture 27.

Advised. — French or German 25 to 27 or 28 to 30, Chemistry 25; the other subjects (except Entomology) in the last three columns above are merely suggested as desirable to choose from.

MICROBIOLOGY. (Major.)

Professor CHARLES E. MARSHALL, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Chemistry	51 **I.**	8
Chemistry	52 **II.**	8
Microbiology or	50 **I.**	
Microbiology or	50 **II.**	5
Microbiology	50 **III.**	
Microbiology or	51 **II.**	5
Microbiology	51 **III.**	
Microbiology	52 **III.**	5
Microbiology or	81 **I.**	
Microbiology or	82 **I.**	5
Microbiology	83 **III.**	
Microbiology or	80 **II.**	
Microbiology or	75 **II.**	5
Dairying	51 **III.**	
Microbiology	76 **III.**	5
		46

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25	3	Microbiology 50	5	Microbiology 81	5
	German or French 25 or 28	3	Chemistry 51	8	Microbiology 82	5
II.	German or French 26 or 29	3	Microbiology 51	5	Microbiology 75	5
			Chemistry 52	8	Microbiology 80	5
			Microbiology 50	5		
III.	Chemistry 27	5	Dairying 51	5	Microbiology 76	5
	German or French 27 or 30	3	Microbiology 50	5	Microbiology 83	5
	Physics 27	5	Microbiology 51	5		
			Microbiology 52	5		
IV.						

SOPHOMORE ELECTIVE (RECOMMENDATIONS). — German or French 25 or 28, 26 or 29, 27 or 30, Chemistry 25 and 27, and Physics 27.

ADDITIONAL INFORMATION. — The rest of the sophomore electives allowed are left for the student to choose.

Rural Journalism. (Major.)

——— ———, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Rural Journalism	50 **I.**	3
Rural Journalism	51 **II.**	3
Rural Journalism	52 **III.**	3
Two out of three: —		
Rural Journalism	53 **I.**	3
Rural Journalism	54 **II.**	3
Rural Journalism	55 **III.**	3
Two out of three: —		
Rural Journalism	77 **I.**	3
Rural Journalism	78 **II.**	3
Rural Journalism	79 **III.**	3
One from: —		
Entomology	90 **II.**	3
or		
Animal Husbandry	53 **III.**	
Landscape	75 **I.**	
Chemistry	87 **III.**	
All: —		
Rural Journalism	80 **I.**	4 (5)
Rural Journalism	81 **II.**	4 (5)
Rural Journalism	82 **III.**	4 (5)
Rural Sociology	78 **II.**	5
Agricultural Economics	51 **III.**	5
Economics and Sociology	51 **I.**	5
		45–47

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.			Journalism 50 Journalism 53 Economics and Sociology 51	3 3 5	Journalism 77 Journalism 80	3 4 (5)
II.	Economics and Sociology 26	5	Journalism 51 Journalism 54	3 3	Journalism 78 Journalism 81	3 4 (5)
III.			Journalism 55 Journalism 52 Agricultural Economics 51	3 3 5	Journalism 79 Journalism 82	3 4 (5)
IV.						

Sophomore Prerequisites. — All sophomore English.

Sophomore Recommendations. — French or German; Drawing 25. *For agricultural journalism especially:* Animal Husbandry 25, 26, Chemistry 30, Entomology 26, 27.

Agricultural Economics. (Major.)

Professor Alexander E. Cance, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agricultural Economics	50 **I.**	5
Agricultural Economics	52 **II.**	5
Agricultural Economics	53 **III.**	5
Agricultural Economics	75 **II.**	3
Agricultural Economics	76 **II.**	5
Agricultural Economics	78 **III.**	5
Agricultural Economics or Agricultural Economics	77 **I.** / 79 **I.**	5
Economic Sociology	51 **I.**	5
Economic Sociology	50 **II.**	5
Farm Management	76 **I.**	3
Rural Sociology or Rural Sociology	51 **II.** / 52 **III.**	3
		49

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.			Agricultural Economics 50	5	Agricultural Economics 77	5
			Economic Sociology 51	5	Agricultural Economics 79	5
					Farm Management 76	3
II.			Agricultural Economics 52	5	Agricultural Economics 76	5
			Economic Sociology 50	5	Agricultural Economics 75	5
			Rural Sociology 51	3		
III.			Agricultural Economics 53	5	Agricultural Economics 78	3
			Rural Sociology 52	3		
IV.						

Additional Information. — The sophomore electives are left to the student to choose. Animal Husbandry is suggested for terms I and II, and Economic Sociology for term III.

Agricultural Education. (Major.)

Professor William R. Hart, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agricultural Education	50 **I.**	5
Agricultural Education or	51 **I.**	5
Agricultural Education	51 **II.**	5
Agricultural Education	52 **III.**	5
Agricultural Education	75 **II.**	3
Agricultural Education or	76 **I.**	3
Agricultural Education	76 **III.**	3
Agricultural Education	77 **III.**	5
Agricultural Education or	80 **I.**	1 5
Agricultural Education or	80 **II.**	1–5
Agricultural Education or	80 **III.**	1–5
Agricultural Education	80 **IV.**	1–5

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Animal Husbandry 25	3	Agricultural Education 50	5	Agricultural Education 76	3
	Rural Engineering 25	2	Agricultural Education 51	5	Agricultural Education 80	1–5
II.	Entomology 26	3	Agricultural Education 51	5	Agricultural Education 75	3
	Animal Husbandry 26	3			Agricultural Education 80	1–5
III.	Entomology 27	3	Agricultural Education 52	5	Agricultural Education 76	3
	Horticulture 27	3			Agricultural Education 77	5
	Rural Engineering 26	2			Agricultural Education 80	1–5

Additional Information. — Courses 50, 51, 76 and 80 or their equivalents are required of all candidates for teaching. Credits vary from 14 to 18. Courses 51 and 77 are required of all candidates for county agent work. Students who are intending to teach are recommended to take as many of the sophomore electives listed above as possible in the sophomore year. Programs for juniors and seniors are planned on the basis of individual needs, with a view to the most desirable preparation for the attainment of the student's aim. Some of the aims for which programs are planned are as follows: teaching vocational agriculture; teaching non-agricultural subjects in vocational agricultural schools and departments; teaching agriculture in high schools not of the vocational type; county agent work and Junior Extension work; directing physical education and county Y. M. C. A. work; rural school supervision and rural leadership; positions as supervisors and directors of agricultural teaching; and college positions in Agricultural Education.

Rural Sociology. (Major.)

Professor John Phelan, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Agricultural Economics	50 **I.**	5
Agricultural Economics	52 **II.**	5
Agricultural Economics	53 **III.**	5
Agricultural Economics	75 **II.**	5
Economics and Sociology	51 **I.**	5
Economics and Sociology	50 **II.**	5
Economics and Sociology	75 **I.**	5
Economics and Sociology	77 **III.**	5
Rural Journalism	55 **III.**	3
Rural Sociology	50 **I.**	3
Rural Sociology	51 **II.**	3
Rural Sociology	52 **III.**	3
Rural Sociology	77 **II.**	3
Rural Sociology	79 **I.**	1–3
Rural Sociology	80 **II.**	1–3
Rural Sociology	81 **III.**	1–3
		58–64

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.			Economic Sociology 51	5	Agricultural Economics 50	5
			Rural Sociology 50	3	Economic Sociology 75	5
					Rural Sociology 79	1–3
II.			Economic Sociology 50	5	Agricultural Economics 52	5
			Rural Sociology 51	3	Agricultural Economics 75	5
					Rural Sociology 77	3
					Rural Sociology 80	1–3
III.			Economic Sociology 77	5	Agricultural Economics 53	5
			Rural Journalism 55	3	Rural Sociology 81	1–3
			Rural Sociology 52	3		

Additional Information. — The sophomore electives allowed are left to the student to choose.

Description of Courses

Description of Courses.

DIVISION OF AGRICULTURE.

Professor Foord.

[Heavy-faced Roman numerals indicate the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Freshman Agriculture.

1. **I.** A survey course, continuing throughout the year, intended to put the student in touch with agriculture in all its major aspects, dealing primarily with the problems of Massachusetts farms but not excluding the agriculture of the United States.
1 class hour. 1 2-hour laboratory period, 3 study hours, credit, 6.
Professor Redman in co-operation with the
Divisions of Agriculture and Horticulture.

(For the first term, 1922–23, this work will be Agronomy 1 **I,** which see.)

2. **II.** As stated under Course 1 **I.**
2 class hours. 4 study hours, credit, 6.

3. **III.** As stated under Course 1 **I.**
2 class hours. 1 4-hour laboratory period, 6 study hours, credit, 12.

Agronomy.

Professor Beaumont, Assistant Professor Michels, Mr. Thelin, Mr. Thayer, Mr. Lanphear.

The courses in agronomy are designed to present the fundamental knowledge concerning the soil and the principal products of the field. The basic course in soils is required of all students. The electives purpose to meet the needs of those specializing in soils and field crops and other specialized fields including both pure and applied science.

The laboratories for soils and fertilizers include one for elementary work, supplied with locker equipment for 200 students, and one for advanced work, accommodating 80 students. These laboratories are equipped with steam and electric ovens, balances, centrifuge, microscopes and other apparatus necessary for a study of soils and fertilizers. Storerooms, stock rooms, and balance rooms are conveniently near the laboratories. There is also a workroom attached, equipped with power machinery for grinding soils, fodders and the like.

The crops' laboratories include one for seed study, with lockers for 50 students, and a laboratory for the study of cereals, forage crops, roots, etc., with lockers for 64 students. The equipment of these laboratories includes

steam ovens, constant temperature electric ovens, ovens for seed germination, Brown-Duval moisture apparatus, balances, microscopes, and collections of seeds, grasses, tubers, weeds, etc. A balance room, root cellar and two storerooms, one of which is mouse-proof, are also used for crop work.

A modern steam-heated greenhouse 25 by 35 feet, used for work in soils and crops, is a valuable part of the equipment. Near the greenhouse is a crop garden on which different varieties of corn, grasses, clovers, etc., are grown for demonstration purposes, and as a source of material for class work. In addition, the general college farm of 250 acres is used for field study in soils and crops, and as a source of material.

Required Courses.

1. **I.** Agronomy. — Freshmen. Given as part of the freshman agriculture and horticulture. This course aims, by actual contact with the plants and the plant products, to make the students familiar with the common field, garden and orchard crops of Massachusetts.
1 class hour. 1 2-hour laboratory period, 3 study hours, credit 6.
Assistant Professor Michels and Mr. Thelin.

27. **III.** Soils and Fertilizers. — Sophomores. A study of soils and their properties, soil management, methods of soil improvement and maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments.
4 class hours. 1 2-hour laboratory period, credit, 5.
Professor Beaumont and the Department.
Prerequisite, Freshman-required Chemistry.

Elective Courses.

50. **I.** Field and Forage Crops. — For juniors; seniors may elect. History, classification and production of corn and of those grasses, legumes, root and tuber crops suited to New England conditions. Crops of less importance in New England are briefly considered. The work includes lecture, laboratory and field study.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Michels and Mr. Thelin.
Prerequisites, Agronomy 27, Botany 3.

51. **III.** Advanced Field Crops. — For juniors; seniors may elect. Study of the cereals and other field crops not taken up or only briefly considered in Course 50. General problems of crop production are also considered, and the work is not entirely confined to New England conditions. The laboratory work includes a study of the cereals, the quality of seeds, grains and crop products, crop problems and field work with such crops as are available.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Michels and Mr. Thelin.
Prerequisite, Agronomy 50.

75. **I.** Advanced Soils. — For seniors; juniors may elect. A field, lecture and laboratory course on soils and their adaptability to different uses. The field work consists of a detailed study of soil textures, natural and spontaneous

vegetation and other factors which indicate the fertility and adaptation of the soil; accompanied by a laboratory study of the physical properties of the soils sampled.

2 class hours. 1 4-hour and 1 2-hour laboratory period, credit, 5.
Professor BEAUMONT and the DEPARTMENT.

Prerequisite, Agronomy 27. Advised, Geology 27.

77. **II.** MANURES AND FERTILIZERS. — Seniors. An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Considerable attention is devoted to consideration of the experimental work which has been done, and which is now in progress. The laboratory work consists of a study of fertilizers, fertilizer mixtures, limes and culture work.

3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor BEAUMONT and Mr. LANPHEAR.

Prerequisite, Agronomy 27. Advised, Chemistry 27.

78. **II.** BREEDING OF FIELD CROPS. — Seniors. Deals with the improvement, by selection and breeding, of the crops studied in Courses 50 and 51.

2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor MICHELS.

Prerequisite, Agronomy 51.

Animal Husbandry.

Professor SALISBURY, Assistant Professor RICE, Assistant Professor GLATFELTER, Mr. THAYER.

It is the purpose of this department to present comprehensive information on the subject of animal husbandry. The first courses are studies of the breeds, types and market classes of live stock. These are followed by courses in judging, breeding and management.

The department is equipped with an excellent laboratory, Grinnell Arena, which has a seating capacity of 180. The equipment for classroom instruction includes upwards of 125 head of dairy cattle which are superior representatives of Jersey, Guernsey, Ayrshire and Holstein breeds; considerable numbers of Berkshire and Chester White pigs; pure-bred Percherons; and several work teams of various types. The department has a collection of plaster of Paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine; and a set of over 250 lantern slides portraying the leading prize-winning producing and breeding animals of the principal breeds of horses, cattle, sheep and swine. There is also a collection of the different foodstuffs available for the use of New England farmers. All this equipment is being added to from time to time as funds are available.

Elective Courses.

25. **I.** TYPES AND BREEDS OF LIVE STOCK. — Sophomores. Covers the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Textbook, Plumb's "Breeds and Types of Farm Animals."

2 lectures. 1 2-hour laboratory period, credit, 3.
Professor SALISBURY and Mr. THAYER.

26. **II.** Types and Breeds of Live Stock. — Sophomores. Continuation of Course 25.
2 lectures. 1 2-hour laboratory period, credit, 3.
Professor Salisbury and Mr. Thayer.

50. **I.** Feeds and Feeding. — For juniors. A study of the principles of animal nutrition; of the composition and qualities of feeding materials. Textbook, Henry's "Feeds and Feeding."
3 class hours. Credit, 3.
Assistant Professor Rice.

Prerequisite, Chemistry 30 or 6.

51. **II.** Feeds and Feeding. — For juniors. A study of feeding practice as related to all farm animals. Considerable work will be given in the formulating of rations.
3 class hours. Credit, 3.
Assistant Professor Rice.

Prerequisite, Animal Husbandry 50.

52. **III.** Advanced Stock Judging. — For juniors; seniors may elect. Designed to equip students in the judging of classes of different types of live stock; to strengthen them in the selection of superior sires; and equip them for stock judging at fairs. Visits are made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected from this class.
1 2-hour and 1 4-hour laboratory period, credit, 3.
Professor Salisbury.

Prerequisites, Animal Husbandry 25 and 26.

53. **III.** Principles of Breeding. — For juniors; seniors may elect. Designed to familiarize students with the problems that are involved in animal improvement; to acquaint them with the facts which are already established; to scrutinize prevailing theories; and to indicate the lines and methods of further work. Some of the subjects studied are: variations, their causes and heritability; DeVrie's theory of mutations; the inheritance of acquired characters; the pure line; Mendelian law; the making of new types; the determination of sex; applications to human heredity. A few periods at the end of the course are devoted especially to the application of principles in livestock improvement. Supplementary reading.
3 class hours. Credit, 3.
Assistant Professor Rice.

Prerequisites, Animal Husbandry 25, 26, Zoölogy 25.

75. **I.** Beef and Swine Production. — A study of the leading breeds of beef cattle and swine, together with the work of some of the most successful breeders. Considerable time will be given also to the production of commercial beef and pork. In this course such livestock management problems as apply to beef cattle and swine will be included.
2 lectures. 1 2-hour laboratory period, credit, 3.
Assistant Professor Glatfelter.

Prerequisites, Animal Husbandry 50, 51 and 53.

78. **II.** Horse and Sheep Production. — A study of the production of these animals planned in the same manner as that of the previous course.
2 lectures. 1 2-hour laboratory period, credit, 3.
Professor Salisbury.
Prerequisites, Animal Husbandry 50, 51 and 53.

79. **III.** Dairy Cattle and Milk Production. — A study of the leading breeds of dairy cattle, the most successful breeders and famous breeding animals, advanced registry testing and feeding for production, sales methods and advertising.
2 lectures. 1 2-hour laboratory period, credit, 3.
Professor Salisbury.
Prerequisites, Animal Husbandry 51, 52 and 53.

81. **II.** Dairy and Animal Husbandry. — Seminar for seniors majoring in dairying and animal husbandry.
1 class hour. Credit, 1.
Departments of Dairying and Animal Husbandry.

82. **III.** A continuation of Course 81.
1 class hour. Credit, 1.
Departments of Dairying and Animal Husbandry.

Dairying.

Professor Judkins, Assistant Professor Yaxis, Mr. Pendleton, Mr. Smith.

The dairy manufactures building is new, well lighted and of sanitary construction. It is designed and equipped especially for teaching dairy manufactures. The equipment includes all kinds of machinery that are considered essential to the proper handling of milk and the making of cream, butter, ice cream and soft cheeses.

Course 77 is for students who desire a general idea of dairy work and manufacturing processes. Part of the courses are arranged to give instruction in general dairy work as associated with Massachusetts agriculture; part are arranged to give to a smaller group of students more complete work in dairy manufactures. Those majoring in dairy manufactures should have at least one summer's experience in a commercial plant before graduation.

Elective Courses.

50. **I.** Milk and Milk Composition. — For juniors; seniors may elect. The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for fat, tests for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Yaxis.

51. **III.** Market Milk. — For seniors; juniors may elect. A study of market-milk conditions; extent and development of the business; supply and delivery; food value of milk and its uses as food; milk and its relation to the public health; proper methods for handling milk and cream for direct consumption; certified milk, requirements and production; pasteurizing, sterilizing, standardizing and modifying; milk laws and inspection.
3 class hours. 1 4-hour laboratory period, credit, 5.
Professor Judkins and Mr. Smith.
Prerequisites, Dairying 50, Microbiology 50.

52. **II.** Judging Dairy Products. — For juniors.
1 2-hour laboratory period, credit, 1.
Professor Judkins.

75. **II.** Butter Making. — For juniors; seniors may elect. A study of separators and cream separation; handling milk and cream for butter making; preparation of starters, and ripening cream; churning; markets and their requirements; marketing, scoring and judging butter; management; dairy machinery and care thereof; problems.
2 class hours. 2 3-hour laboratory periods, credit, 5.
Assistant Professor Yaxis.
Prerequisite, Dairying 50.

76. **III.** Milk Products. — For seniors; juniors may elect. The manufacture of milk products other than butter, including cheddar cheese, soft and fancy cheese, ice cream, condensed milk, casein, milk powder, etc. Laboratories, largely the making of soft and fancy cheese and ice cream. Some ice-cream plants will be visited. The cost of this required trip will probably be $12 to $15.
2 class hours. 2 3-hour laboratory periods, credit, 5.
Mr. Pendleton.
Prerequisite, Dairying 51.

77. **III.** Dairying. — For seniors; juniors may elect. A general course primarily for those who wish to take only one course in dairying. The work covers briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary butter making; proper methods of handling milk and cream; and the relation of market milk to the public health.
3 lecture hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Yaxis.

Farm Management.

Professor Foord, Assistant Professor Abell.

The purpose of the courses in this department is to present various considerations of farming as a business. This involves a knowledge of the cost of production and the profit from the different enterprises such as dairy, poultry or orchard; a study of the enterprises, and the relative amounts of each that will give the best use of labor and equipment on the farm under consideration.

The college farm of 250 acres is under the general supervision of the Department of Farm Management, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied. The offices of the department are in Stockbridge Hall.

Elective Courses.

75. **II.** Farm Accounts and Cost Accounting. — For seniors; juniors may elect. A study of farm inventories, single-enterprise accounts, complete farm accounts and farm records. Special emphasis is given to the interpretation of results and their application in the organization and management of the farm.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professors Foord and Abell.

76. **I.** Farm Management. — For seniors; juniors may elect. A study of farming as a business; regions and types of farming; the general principles of farm management and the influence of size, production, live stock and crop farming on the farmer's labor income; arrangement of fields and buildings; use of land, capital and labor; choosing and buying a farm.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Abell.
Prerequisites, Agronomy 50, Animal Husbandry 25 and 26, and some farm experience.

77. **III.** Farm Management. — For seniors; juniors may elect. A further and more specific study of the principles and practices as outlined in Course 76, with reference to their application to different regions of the United States and especially to New England. Trips to successful farms are a required part of the course.
1 class hour. 1 4-hour laboratory period, credit, 3.
Professors Foord and Abell.
Prerequisites, Farm Management 75 and 76.

78. **II.** Seminar. — For seniors majoring in general agriculture; others by arrangement.
1 class hour. Credit, 1.
The Department.

79. **III.** Seminar. — For seniors majoring in general agriculture; others by arrangement.
1 class hour. Credit, 1.
The Department.

Poultry Husbandry.

Professor Graham, Professor Sanctuary, Assistant Professor Banta, Mr. Taylor.

The introductory courses (50, 51, 52) give a knowledge of the general routine of elementary poultry keeping. The advanced studies prepare men for the successful operation of poultry plants, either as owners or managers. Graduate work, preparation for further teaching, extension or investigation.

The poultry plant consists of 8 acres of land sloping gently to the west. The buildings consist of three incubator cellars equipped with a number of lamp incubators and two mammoth machines with a total capacity of 9,000 eggs; a pipe brooder house (open pipe system) and 40 colony brooder houses which give a brooding capacity for 7,000 chicks, the equipment for these houses including a large variety of coal-stove brooders and kerosene hovers; a long laying house 14 by 180 feet, which accommodates 500 layers, furnishing facilities for student work in pen management, utility and fancy judging, etc.; and a laboratory 14 by 80, for killing, picking, drawing, trussing, packing, crate fattening and cramming. The fattening equipment consists of a modern sanitary all-steel battery with 16 compartments and 10 wooden crates, accommodating, altogether, 350 birds. There are also a storage building, 28 by 64 feet, for root cellar, poultry carpentry, poultry mechanics, feed room and storage; an experimental breeding house, 18 by 60; a combination laying, testing and breeding house, 18 by 72, for experimental purposes; a model laying house, 18 by 30, for 100 hens, and a house 20 by 40, for 200 hens. The six old experiment-station houses, each 12 by 18 feet, are used as special mating and overflow pens. The total capacity for laying hens is 1,600. A manure shed 14 by 18 feet; an oil and tool house 10 by 12; an incinerator 10 by 10; and two backyard model poultry houses 8 by 10 and 8 by 8 give a total of 76 buildings, not including a pheasant run, 16 roosting sheds 10 by 10, and numerous small coops for natural incubation and brooding.

Elective Courses.

50. **I.** Poultry Feeds and Feeding. — For juniors; seniors may elect. A study of the principles and practices of poultry nutrition and their relationship to other poultry problems. An important part of the work will be the practical management of a pen of birds for a period of weeks, including observations and detailed record keeping.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Banta.

51. **II.** Poultry Housing and Sanitation. — For juniors; seniors may elect. A consideration of the biological and economic principles fundamental in the efficient designing, practical construction and equipping poultry farm buildings; also of external parasites and the insecticidal agents for their control.
3 class hours. Credit, 3.
Assistant Professor Banta.
Prerequisite, Poultry 50.

52. **III.** Incubation, Brooding and Growing. — For juniors; seniors may elect. A study of the fundamental principles of incubation and rearing

chicks; also of modern equipment, including small and mammoth incubators and various types of brooding apparatus.

3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor SANCTUARY and Mr. TAYLOR.

Prerequisite, Poultry 51.

75. **I.** JUDGING AND CULLING. — Seniors. A study of the origin and evolution of our standard breeds and varieties. Judging for production quality, using trap-nested birds; culling the flock; judging exhibition quality by score card and comparison. Several farms will be visited, also several of the leading Connecticut Valley Poultry Shows. Poultry Judging Teams competing in the Intercollegiate Contest at Madison Square Garden are trained in this course.

2 class hours. 2 3-hour laboratory periods, credit, 5.
Assistant Professor BANTA.

Prerequisite, Poultry 52.

76. **I.** MARKET POULTRY AND POULTRY PRODUCTS. — Seniors. A study of the market classes of poultry, eggs and feathers, the requirements of different markets, methods of marketing, the cold storage of poultry and eggs. Preserving eggs, judging and scoring of live and dressed market poultry and market eggs are important features. Students are required to fatten pens of chickens by different methods and rations, keeping accurate data of the gains in weight and quality, also the costs of feed and labor, and resultant profit or loss. The annual market poultry show is staged under the direction of members of this class.

2 class hours. 2 2-hour laboratory periods, credit, 4.
Professor GRAHAM and Mr. TAYLOR.

Prerequisite, Poultry 52.

77. **II.** POULTRY BREEDING. — Seniors. A study of the principles of breeding and their application to poultry. Practice work in record keeping, pedigree hatching, stud and flock mating will be required as the season permits.

4 class hours. 1 2-hour laboratory period, credit, 5.
Professor SANCTUARY.

78. **III.** FARM POULTRY. — Seniors; juniors may elect. For those students who desire a general knowledge of poultry husbandry but who cannot devote more than one term to the subject; it is not intended for students specializing in poultry, and such students are admitted only by special permission. Emphasis is placed on the farm flock and its economic management. Utility classification, housing, culling, feeding, hatching, rearing, production, marketing and disease control receive special consideration.

3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor BANTA.

79. **III.** POULTRY FARM ORGANIZATION. — Seniors. A study of the organization of the poultry farm for greatest efficiency. The layout of fields and buildings, crop rotations, records, accounts and advertising will receive consideration. One or more trips will be made to representative successful poultry farms.

3 class hours. 1 2-hour laboratory period, credit, 4.
Professor GRAHAM.

Prerequisite, Poultry 77.

Rural Engineering.

Professor Gunness, Assistant Professor Strahan, Mr. Pushee, Mr. Newlon.

The courses in rural engineering are planned to give a working knowledge of those phases of engineering which apply directly to the farm. It is expected that the student will acquire a clear understanding of modern farm practice as it relates to permanent improvements of the farm and the farmstead, and in the selection and use of farm equipment.

This department has an office and the use of a lecture room in Stockbridge Hall. The work on farm structures is given in the large drawing room in the same building. This room is fitted with thirty drawing tables. Models and blue prints are available for the study of farm buildings. A set of post molds and a machine for making cement tile afford opportunity for practical work with cement.

The rural engineering shop is a one-story structure 68 by 126 feet. The carpenter shop in this building is fitted with benches fully equipped with tools for each student. The general repair shop is equipped with forges, benches, a drill press and grinders. The laboratory for farm machinery and farm motors is equipped with a complete line of field machines, gasoline engines, tractors and pumps. A complete assortment of engine accessories, consisting of carburetors, magnetos, etc., is available for thorough instruction in gas engines. A small dynamo and switchboard are used in the study of farm-lighting systems. The work on the small field machines is given in the basement of Stockbridge Hall, and the work on steam engines and steam heating is given in Flint Laboratory.

Elective Courses.

25. **I.** Carpentry. — For sophomores; juniors and seniors may elect. Practice in the use of tools by exercises in bench work, repair of farm equipment and farm building construction.

2 2-hour laboratory periods, credit, 2.
Mr. Pushee.

26. **III.** Repair of Farm Equipment. — For sophomores; juniors and seniors may elect. Exercises in forge work, pipe fitting, soldering, babbitting and fitting bearings, lining up shafting, lacing belts and splicing rope. Practice in the use of machinist's tools, such as file, cold chisel, drill press, taps and dies.

2 2-hour laboratory periods, credit, 2.
Mr. Newlon.

52. **III.** Farm Engineering. — A general course dealing with field implements, gas engines, water supply, lighting, sewage disposal, farm buildings, drainage and irrigation.

3 class hours. 2 2-hour laboratory periods, credit, 5.
The Department.

75. **I.** Farm Structures. — For seniors; juniors may elect. Study of the strength and durability of building materials; water supply; lighting and heating systems for the farm; lightning protection; drawing plans, writing

specifications and estimating the cost of buildings; concrete construction as applied to foundations, silos, tanks, posts, floors and walks.

2 class hours. 2 2-hour laboratory periods, credit, 4.
Assistant Professor STRAHAN.

Prerequisite, Rural Engineering 52 or Landscape Gardening 50.

78. **II** and **III**. FARM MACHINERY. — For seniors; juniors may elect. Study of the care and operation of tillage, seeding, harvesting, pumping and spraying machinery; steam and gas engines and gas tractors. Special attention is given to the use of power on the small farm.

3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor GUNNESS.

79. **III.** DRAINAGE AND IRRIGATION ENGINEERING. — For seniors; juniors may elect. Covers the engineering phase of drainage and irrigation. The various systems are studied, and practice is given in the design of drainage and irrigation systems. Field work gives practice in surveying for drains, platting, locating drains, erecting batterboards and laying tile. Practice is given in assembling equipment for spray irrigation, and the flow of water through nozzles is studied by means of laboratory tests.

2 class hours. 1 2-hour and 1 4-hour laboratory period, credit, 5.
Assistant Professor STRAHAN.

81. **III.** DAIRY MECHANICS. — A study of dairy machinery, including steam boilers, engines, pumps, traps, refrigeration machinery, and heat-controlling devices. Practice is given in pipe fitting, packing valves, lacing belts, and similar repair jobs on the equipment used in dairy plants. Not given in 1922–23.

1 lecture. 1 4-hour laboratory period, credit, 3.
Professor GUNNESS and Mr. NEWLON.

DIVISION OF HORTICULTURE.

Professor Waugh.

[Heavy-faced Roman numerals indicate the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Floriculture.

Professor Thayer, Assistant Professor Muller.

The courses in floriculture are intended to present a general knowledge of all phases of greenhouse design, construction, heating and management, the culture of florists' crops (under glass and in the field), floral decoration and arrangement. The department aims to train students so that they may take up commercial floriculture (either in the growing or retail business) and the management of conservatories on private estates, in parks and cemeteries.

The department is especially well equipped for the teaching work, probably being surpassed in no other agricultural college. French Hall, with its laboratories, classrooms and offices, furnishes excellent facilities for the purposes of instruction. The glass area of the department consists of approximately 20,000 square feet, divided as follows: French Hall range of 7,200 square feet, a durable, practical, commercial range composed of palm and fern, violet, carnation, rose and students' houses; the old Durfee range of 7,400 square feet, devoted to the growing of decorative, conservatory and bedding plants and chrysanthemums; one house of 3,200 square feet, suitable for propagating work and general plant culture; and approximately 2,200 square feet in cold frames and hotbeds.

In addition, the department has 2 acres of land used for the summer culture of carnations, violets, gladioli, dahlias, sweet peas, bedding plants, etc. This also includes a small garden of about 4,700 square feet devoted to the culture of annuals. A large collection of biennials and herbaceous perennials is maintained and is being enlarged from year to year; at the present time the collection consists of several hundred species and varieties, and provides an excellent opportunity for the study of garden flowers.

Elective Courses.

50. **I.** Greenhouse Management. — For juniors; seniors may elect. Designed to familiarize students with the methods followed in the management of greenhouses and of greenhouse crops and the principles underlying the same; history and development of the floricultural industry; preparation of soils; fertilizers; potting; watering; ventilation; control of insects and diseases; methods of plant propagation; forcing of plants. At some time during the term the members of the class will be required to take a one-day trip to visit large commercial establishments. Lectures, assigned readings, reports and laboratory practice.

2 class hours. 2 2-hour laboratory periods, credit, 4.

Professor Thayer.

Prerequisite, Horticulture 27.

51. **II.** Greenhouse Management. — For juniors; seniors may elect. Continuation of Course 50. Several field trips, to study floricultural establishments in the vicinity, will be made during the laboratory periods.
2 class hours. 1 4-hour laboratory period, credit, 4.
Professor Thayer.

52. **III.** Floral Arrangement. — A study of the principles underlying the arrangement and use of cut flowers and plants; funeral designs, basket and vase arrangement, table decorations, home, church and all interior decorations; a study of color as applied to such work. Lectures, assigned readings and reports. This course will be limited to ten students.
2 class hours. 2 2-hour laboratory periods, credit, 4.
Professor Thayer.

53. **I.** Greenhouse Construction and Heating. — For juniors; seniors may elect. The location, types, arrangement, construction, cost, equipment, heating and ventilating of greenhouse structures; the drawing of plans and study of specifications for commercial houses and conservatory ranges. Such practical work as glazing and the construction of concrete benches and cold frames is included as facilities allow. Lectures, assigned readings and problems.
3 class hours. 1 2-hour laboratory period, credit, 4.
Professor Thayer.

55. **III.** Garden Flowers and Bedding Plants. — Juniors and seniors. A study of the annuals, biennials, herbaceous perennials, bulbs, bedding plants and roses that are valuable for use in floricultural or landscape gardening work. Methods of propagation, culture and uses of the various plants are considered; identification of material. Lectures, assigned readings and reports.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Thayer and Assistant Professor Muller.

75. **I.** Commercial Floriculture. — Seniors. A detailed study of the important commercial cut flower crops and potted plants. Visits will be made to commercial establishments during the term. The lectures are supplemented with textbooks and assigned readings.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Muller.

Prerequisite, Floriculture 51.

76. **II.** Commercial Floriculture. — Seniors. As stated under Course 75.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Thayer.

Prerequisite, Floriculture 75.

77. **III.** Commercial Floriculture. — Seniors. As stated under Course 75.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Thayer.

Prerequisite, Floriculture 76.

79. **II.** Conservatory Plants. — Seniors. A study of the foliage and flowering plants used in conservatory work; methods of propagation, culture, use and arrangement; identification of plants. Lectures, assigned readings and reports.

2 class hours. 1 2-hour laboratory period, credit, 3.

Professor Thayer.

Prerequisite, Floriculture 51.

80. **III.** Seminar. — For seniors majoring in floriculture. Advanced study of subjects pertaining to some phase of floriculture. All students are assigned specific problems and pursue study in these problems by reading and research; the results of this study must be presented in the form of a thesis. Seminars are conducted weekly.

2 to 6 laboratory hours, not to exceed 3 credits.

Professor Thayer and Assistant Professor Muller.

Forestry.

Professor Grose.

The forestry courses are intended primarily for prospective owners or managers of farm woodlots, and the field work is focused on typical New England problems. These courses are broad enough, however, to furnish valuable preparation for students planning to study forestry in graduate schools.

The department has an unusually complete equipment of the various instruments used in forest mensuration, forest mapping and engineering, timber estimating, log scaling, board measuring, etc.; and a large assortment of boards illustrative of the various commercial woods found in the lumber markets. The State Forest Nursery, comprising 6 acres of land and containing, approximately, 5,000,000 trees, transplants and seedlings, is on the college farm. Forests containing every variety of tree common to New England are within walking distance of the college. The college campus affords an arboretum containing a large number of trees not native to New England. The Mount Toby Demonstration Forest has an area of approximately 750 acres, and contains the various types of forest growth found throughout the State. It serves as a field laboratory in which students have the privilege of working out problems in silviculture, forest mensuration and management. Improvement cuttings, cuttings for utilization, and forest plantings are conducted by the department.

55. **I.** Woodlot Forestry: Estimating and Business Management. — For juniors and seniors. Topics: forest mapping; timber-cruising, determining rate of growth and possible cut; financial returns; forest taxation; our national timber supply, present and future.

1 2-hour and 1 4-hour laboratory period, credit, 3.

Professor Grose.

56. **II.** Woodlot Forestry: Logging, Milling and Marketing. — For juniors and seniors. Topics: felling trees; sawing logs; hauling logs; the portable mill; the stationary mill; seasoning, measuring and shipping lumber;

lumber grades and prices; legal forms; by-products of the woodlot; adaptability of species to uses; wood-using industries of Massachusetts.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor GROSE.

57. **III.** WOODLOT FORESTRY: TIMBER-RAISING. — For juniors and seniors. Topics: forest planting; weeding; release cuttings; pruning; thinning; salvage cutting; protection from insects, fungi, fire, etc.; final cutting methods for natural reproduction of the forest.
1 2-hour and 1 4-hour laboratory period, credit, 3.
Professor GROSE.

58. **III.** WOODLOT FORESTRY: BRIEF SURVEY. — A condensation of Courses 55, 56 and 57 for those who have only one term to give to forestry.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor GROSE.

Horticultural Manufactures.

Professor CHENOWETH, Mr. ROBERTSON.

The courses aim to give a practical knowledge of the problems connected with food preservation. Emphasis is placed upon the conservation of the cheaper grades of fruits and vegetables, to the end that the whole crop may be marketed at a profit and that wholesome food products may result from what would otherwise be lost. The social and economic values of this work are constantly emphasized.

The department occupies three laboratory rooms in Flint Laboratory, two in Fisher Laboratory, with offices in Wilder Hall and French Hall. The general equipment of the department, both for the use of students and for manufacturing purposes, may be grouped under the following heads: —

1. *Canning.* — A modern canning outfit, including both steam-pressure cookers and hot-water baths, hand and power can sealers, peeling and slicing machines, a string-bean cutter, heat-penetration thermometers, electric incubator and a large assortment of all types of home canning equipment.

2. *Evaporation.* — Two small orchard evaporators, a tunnel drier, peeling machines, slicers and a general assortment of driers adapted to home evaporation.

3. *Fruit Juices, Butters, etc.* — A hand cider mill, a motor-driven hydraulic press, a steam-jacketed kettle, an apple-butter cooker, and cider and vinegar testing apparatus.

Elective Courses.

75. **I** and **III.** HORTICULTURAL MANUFACTURES. — For seniors and graduate students. A practical course in food preservation dealing primarily with fruits and vegetables. The canning of fruits and vegetables as practiced in the home and in commercial canneries; evaporation of fruits and vegetables, the various types of equipment and methods of preparation of products. The manufacture of (*a*) fruit products, such as butters, jams, jellies, fruit juices, marmalades, preserves, vinegars, pastes, etc.; (*b*) vegetable products, as pickles, piccalilli, sauerkraut, soups, etc. Particular attention is given to study and use of all types of equipment suitable for use in the home or small factory, together with methods for testing a large variety of manufactured

products. The emphasis is on canning, drying and study of equipment. This course will be repeated as nearly as possible in the spring term of 1922–23.
2 class hours. 3 2-hour laboratory periods per week, credit, 5.
Professor CHENOWETH.

76. **II.** HORTICULTURAL MANUFACTURES. — For seniors and graduate students. A continuation of Course 75. The emphasis in this course is placed on the manufacturing and testing of fruit and vegetable products.
1 class hour. 2 laboratory periods per week, credit, 3.
Professor CHENOWETH.
Prerequisite, Horticultural Manufactures 75.

77. **III.** HORTICULTURAL MANUFACTURES. — Continuation of courses 75 and 76, dealing primarily with maple products, the canning of meats and spring vegetables, and studies of special problems involved in establishing and operating home and farm factories.
2 2-hour periods per week, credit, 2.
Professor CHENOWETH.

Horticulture.

Professor WAUGH, Assistant Professor THOMPSON, Assistant Professor ROGERS.

The general subject of horticulture divides naturally into subjects of pomology, floriculture, forestry, landscape gardening and vegetable gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.

Elective Courses (General).

27. **III.** NURSERY PRACTICE. — For sophomores; juniors and seniors may elect. Treats of the fundamental methods of plant propagations by seeds, cuttings, budding, grafting, etc. Lectures and practicums.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor THOMPSON.

50. **I.** PLANT MATERIALS. — For juniors; seniors may elect. Aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor THOMPSON.
Prerequisite, Horticulture 27.

51. **III.** PLANT MATERIALS. — For juniors; seniors may elect. A continuation of Course 50, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor THOMPSON.
Prerequisite, Horticulture 50.

Landscape Gardening.

Professor WAUGH, Assistant Professor HARRISON.

The purposes of the courses are: (1) To train men for the profession in all its branches. As a rule graduates should first enter the employ of established landscape architects, nurserymen or park superintendents, and after an apprenticeship of several years those who have the requisite technical and business ability may set up for themselves. (2) To train men for public-service work in national, State and municipal parks and forests. (3) To train men for country planning, this function being exercised through various public institutions and organizations. (4) To train teachers and extension workers in lines of landscape gardening and civic improvement. (5) To give a broad and liberal general education stressing the fundamental principles of art.

The department has large, well-lighted drafting rooms, with necessary equipment, such as planimeters, eidograph, pantograph, blue-printing outfit, etc.; and a complete outfit of surveying instruments, including transits, levels, plane tables, prismatic compasses, hand levels, etc. The college campus presents an unusually good collection of the plant materials used in landscape gardening.

Elective Courses.

50. **I.** MAPPING AND TOPOGRAPHY. — Juniors. Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Must be followed by Course 51.

2 2-hour laboratory periods; 2 3-hour laboratory periods, credit, 5.
Assistant Professor HARRISON.

Prerequisites, Mathematics 26 and 27, Drawing 25, 26 and 27, Horticulture 27.

51. **II.** ELEMENTS OF LANDSCAPE GARDENING. — Juniors. As stated under Course 50.

3 3-hour laboratory periods, credit, 4.
Assistant Professor HARRISON.

Prerequisite, Landscape Gardening 50.

52. **III.** GENERAL DESIGN. — Juniors. Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens, parks and private grounds; written reports on individual problems.

2 2-hour laboratory periods; 2 3-hour laboratory periods, credit, 5.
Assistant Professor HARRISON.

Prerequisites, Landscape Gardening 50 and 51, and either plant materials (Horticulture 50 and 51) or advanced mathematics.

75. **I.** THEORY OF LANDSCAPE ART. — For seniors and graduates. The general theory and applications of landscape study, including a brief history of the art.

3 class hours. Credit, 3.
Professor WAUGH.

76. **I.** Civic Art. — Seniors. The principles and applications of modern civic art, including city planning, city improvement, village improvement and rural improvement, with special emphasis upon country planning. Must be followed by Course 77.

3 3-hour laboratory periods, credit, 4.
Professor Waugh.

Prerequisite, Landscape Gardening 52.

77. **III.** Country Planning. — Seniors. As stated under Course 76.

3 3-hour laboratory periods, credit, 4.
Professor Waugh.

Prerequisite, Landscape Gardening 76.

78. **II.** Architecture. — Alternating with Course 79; given in 1922–23. Juniors and seniors. The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing.

3 class hours. Credit, 3.
Assistant Professor Harrison.

79. **II.** Construction and Maintenance. — Alternating with Course 78; given in 1923–24. Juniors and seniors. Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc.

3 class hours. Credit, 3.
Assistant Professor Harrison.

80. **I.** Theory of Design. — Juniors. As stated under Course 52. [Will be given in the summer term when that is established; meantime, will be given in term **I**, senior year.]

120 laboratory hours, credit, 4.
Professor Waugh.

Prerequisite, Landscape Gardening 52.

81. **II.** Estate Design.

3 3-hour laboratory periods, credit, 4.
Assistant Professor Harrison.

82. **III.** Park Design.

3 3-hour laboratory periods, credit, 4.
Assistant Professor Harrison.

Pomology.

Professor Sears, Assistant Professor Drain, Assistant Professor French, Assistant Professor Gould, Mr. Mack.

The object of the courses is to give a training which shall be thoroughly practical and yet scientific. This will fit the men to enter the field of practical fruit-growing, or it will furnish an excellent foundation for further study.

The department has 50 acres in fruit plantations. The apple orchards comprise about 35 acres, and there are blocks of pears, peaches, plums and cherries. In small fruits there are plantings of strawberries, raspberries, blackberries, currants and gooseberries. There are three vineyards, with a total area of 5 acres, in which the leading varieties and the principal types of pruning and training are represented. In these plantations are 50 varieties of grapes, representing three native American species and many hybrids; 20 varieties of peaches; 20 varieties of pears; 25 of plums, including five species and many hybrids; and 100 varieties of apples.

The department has an excellent equipment of spraying and dusting machinery, including various styles and sizes of power sprayers, and many types of barrel pumps and smaller sprayers. There is also an excellent assortment of orchard tools, including plows, harrows, fertilizer sowers, etc.

Fisher Laboratory is one of the best planned and equipped packing and storage plants in the United States. It includes six refrigerated rooms; four storage rooms not refrigerated; one large laboratory room and one classroom, besides ample storage room for fruit packages and equipment. The equipment for the building itself includes four types of apple sizers; packing tables and box and barrel presses of various types, besides all kinds of packages and the smaller equipment necessary for thoroughly modern work in grading and packing fruit. The department is equipped with lockers and with pruning and other tools for the use of students in laboratory work, which is made a leading feature in all the courses in pomology.

Elective Courses.

50. **I.** Practical Pomology. — For juniors; seniors may elect. A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of nursery stock, pruning, culture of orchards, orchard fertilizers, cropping orchards, etc. Lectures, supplemented with text and reference books; field and laboratory exercises.

2 class hours. 1 2-hour laboratory period, credit, 3.

Professor Sears.

Prerequisite, Horticulture 27.

51. **II.** Practical Pomology. — For juniors; seniors may elect. As stated under Course 50.

2 class hours. 1 2-hour laboratory period, credit, 3.

Professor Sears.

Prerequisite, Pomology 50.

52. **III.** Small Fruits. — For juniors; seniors may elect. A study of the growing of small fruits, including raspberries, blackberries, strawberries, currants, gooseberries and grapes, dealing with such questions as their propagation, selecting a site for the plantation, soils, fertilizers, pruning, spraying, etc.

2 class hours. 1 2-hour laboratory period, credit, 3.

Professor Sears.

Prerequisite, Pomology 51.

54. **II.** Systematic Pomology. — Seniors. A study of the varieties and nomenclature of the different fruits, with critical descriptions; special reference given to relationships and classification. Lectures, laboratory and field exercises.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Mr. Mack.

Prerequisite, Pomology 52.

75. **I.** Systematic Pomology. — Seniors. As stated under Course 54.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Drain.

Prerequisite, Pomology 54.

76. **II.** Practical Pomology. — For juniors; seniors may elect. As stated under Course 50.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Sears.

Prerequisite, Pomology 51.

77. **I.** Commercial Pomology. — Seniors only, majoring in pomology. The picking, handling, storing and marketing of fruits, including a discussion of storage houses, fruit packages, methods of grading and packing. Especial emphasis is placed upon laboratory and field work, where the student is given actual practice in the picking and packing of all the principal fruits.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Gould.

Prerequisite, Pomology 51.

78. **III.** Spraying. — Seniors. A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small-fruit plantations.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Drain.

Prerequisite, Pomology 76.

79. **II.** General Pomology. — For seniors; juniors may elect. Planned to meet the needs of students who cannot devote more than one term to the subject but who want a general knowledge of fruit growing. Consists of lectures and laboratory exercises on such topics as choosing the locations, kinds and varieties of fruits to grow, securing and setting the plants, care and cultivation, pruning, spraying, pests, harvesting and storing.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Drain.

80. **I.** Seminar. — For seniors majoring in pomology. Advanced study of problems relating to the business of fruit growing. Each student is assigned a major and a minor problem in lines of work in which he is particularly interested. He pursues his studies both by reading and research, and the materials obtained will be worked into theses which are presented to the seminar for discussion. No lectures are given, but seminar meetings are held for one period each week.

Credit, 1.
The Department.

81. **II.** Seminar. — For seniors majoring in pomology. A continuation of Course 80. One seminar meeting each week.

Credit, 1.
The Department.

82. **III.** Seminar. — For seniors majoring in pomology. A continuation of Course 81. One seminar meeting each week.

Credit, 1.
The Department.

Vegetable Gardening.

Professor Tompson, Assistant Professor Harris, Mr. Snyder.

The courses cover the principles and practices of the commercial production of vegetables in the open, and the forcing of vegetables in cold frames, hotbeds and greenhouses. They are designed for students who wish to engage in the business for themselves or for others, or who wish to become teachers or investigators in the more technical phases of the subject.

The department has 12 acres of land, greenhouses, hotbeds and cold frames, with modern equipment devoted to the production of a wide variety of crops. These afford excellent subject-matter for study, and opportunity for close contact with the actual problems of the business.

Elective Courses.

50. **III.** General Vegetable Gardening. — Juniors; seniors may elect. A general course for students not specializing in vegetable gardening. Designed to teach the fundamentals of vegetable gardening, soils, fertilizers, garden crops, general methods of management.

2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Harris.

52. **II.** Practical Vegetable Gardening. — Juniors; seniors may elect. A study of the principles of vegetable gardening. Deals with such questions as the selection of a location; soils, manures and fertilizers, green manure and cover crops; seeds and seeding; the construction and management of hotbeds and cold frames; garden planning, planting, tillage, irrigation; control of insects and diseases; harvesting, marketing and storing. Includes a detailed study of the cultural requirements of the common vegetable crops, and the principles of rotation and double cropping. Text and reference books. Laboratory and field exercises.

3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Harris.

Prerequisites, Horticulture 27, Agronomy 75.

53. **III.** Practical Vegetable Gardening. — Juniors; seniors may elect. As stated under Course 52.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Harris.
Prerequisite, Vegetable Gardening 52.

75. **I.** Systematic Vegetable Gardening. — Seniors. Includes the systematic study of varieties, types and strains of the leading vegetable crops; the establishing of types, determination of quality of varieties; seed growing, variety improvement, rogueing, seed harvesting, curing and storing.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Harris.
Prerequisite, Vegetable Gardening 53.

76. **II.** Greenhouse Construction and Vegetable Forcing. — Seniors. A study of types, materials, construction, location, arrangement, capacity and cost of greenhouses for growing vegetables. A brief consideration of the heating plant, — the type, installation, piping and management; also the study of greenhouse vegetable crops and their production as practiced by commercial growers.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Harris.
Prerequisite, Vegetable Gardening 75.

77. **III.** Commercial Vegetable Growing. — Seniors. A consideration of vegetable growing as a business. A study of this specialized type of farming, including places where developed, types, extent, economic importance, capitalization, equipment and other fundamental problems of commercial vegetable gardening. Students assist in the planning and operation of a typical market-gardening area. Visits are made to market-gardening and truck-gardening farms.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Harris.
Prerequisite, Vegetable Gardening 76.

Drawing.

Elective Courses.

25. **I.** Free-hand Drawing. — For sophomores; juniors and seniors may elect. Lettering; free-hand perspective; sketching from type models, leaves, flowers and trees, houses, etc.; laying flat and graded washes in water colors; water-color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink.
3 2-hour laboratory periods, credit, 3.

26. **II.** Mechanical Drawing. — For sophomores; juniors and seniors may elect. Inking exercises; geometric problems; projection; intersections;

isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry.

3 2-hour laboratory periods, credit, 3.

27. **III.** Mechanical Drawing. — For sophomores; juniors and seniors may elect. As stated under Course 26.

3 2-hour laboratory periods, credit, 3.

Prerequisite, Drawing 26.

DIVISION OF SCIENCE.

Professor Fernald.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Botany.

Professor Osmun, Assistant Professor Clark, Assistant Professor McLaughlin, Assistant Professor Torrey, Assistant Professor Davis.

A knowledge of the principles of plant life is fundamental in agricultural education. The required courses in botany are planned with this and the general educational value of the subject in view. Elective courses are of two types: (1) those which have for their chief aim the direct support of technical courses in agriculture and horticulture, and (2) those providing broader, more intensive training in the science. Courses in the second group may lead, when followed by postgraduate study, to specialization in the field. They also furnish excellent training for those specializing in other sciences and in scientific agriculture. In all undergraduate courses the relation of the science of botany to agriculture is emphasized.

The department occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. The building has two lecture rooms with seating capacity of 154 and 72, respectively; one seminar and herbarium room; large laboratories for general and special work; and smaller rooms for advanced students. A glass-enclosed laboratory for plant physiology adjoins the main building and provides unusual facilities for the study of phenomena of plant life. In addition, a greenhouse 28 by 70 feet is connected with the building. This is for experimental work in plant pathology and physiology, and for growing plants needed for instruction. The experiment station laboratories devoted to botanical research are in this building.

The laboratories and lecture rooms are of modern construction, finely lighted, and equipped with compound and dissecting microscopes, microtomes, paraffin and drying ovens, physiological and other apparatus, and a large collection of charts. The herbarium contains about 20,000 sheets of seed plants and ferns, 1,200 sheets of liverworts and mosses, and 25,000 specimens of fungi. Facilities and equipment for the study of plant physiology and pathology are excelled in few other institutions.

Required Courses.

3. **III.** Introductory Botany. — Freshmen. Presents the seed plants as plastic organisms molded by their environment. Also introduces the student to methods of identifying and classifying plants.

An herbarium, illustrative of systematic, ecological and economic features, is started in the spring, but need not be presented until fall when credit is given in Course 25. This makes it possible for the interested student to familiarize himself with the flora of the full growing season.

1 class hour. 2 2-hour laboratory periods, 4 study hours, credit, 9.

Assistant Professors Torrey and McLaughlin.

25. **I.** Introductory Botany. — Sophomores. The anatomy and physiology of the seed plants (Phanerogamia), with a brief summary of the lower forms of plant life. The herbarium started in connection with Botany 3 is presented as part of this course.

1 class hour. 2 2-hour laboratory periods, credit, 3.

Assistant Professor Torrey.

Prerequisite, Botany 3.

Elective Courses.

26. **II.** Morphology and Taxonomy of the Lower Plants (Cryptogamia). — Sophomores. Systematic study of typical forms of bacteria, algæ, fungi, lichens, mosses, ferns. (Courses 3, 25 and 26 constitute a general elementary course in botany, and are required of all students who major in the subject.)

1 class hour. 2 2-hour laboratory periods, credit, 3.

Professors Osmun and Torrey.

Prerequisite, Botany 25.

27. **III.** The Vascular Plants. — For sophomores; juniors and seniors may elect. Continues the work of Botany 26, but deals with the higher plants, such as ferns and fernworts, gymnosperms and angiosperms. The department possesses a unique collection of lantern slides and microscopical preparations for use in this course.

1 class hour. 2 2-hour laboratory periods, credit, 3.

Assistant Professor Torrey.

Prerequisite, Botany 26.

50. **I.** Diseases of Crops. — For juniors; seniors may elect. The lectures are general and are taken by all who elect the course, but in order to permit students to specialize on the diseases of crops most closely related to their majors or in which they are most interested, the course is divided for laboratory work into the following sections: (I) diseases of truck and field crops; (II) diseases of floricultural crops and ornamentals; (III) diseases of fruit crops; (IV) diseases of shade and forest trees. One, two or three laboratory sections may be taken.

1 class hour. 1, 2 or 3 2-hour laboratory periods, credits, 2, 3 or 4.

Assistant Professor McLaughlin.

Prerequisites, Botany 3 and 25.

51. **II.** Diseases of Crops. — For juniors; seniors may elect. As stated under Course 50.

1 class hour. 1, 2 or 3 2-hour laboratory periods, credits, 2, 3 or 4.

Assistant Professor McLaughlin.

Prerequisite, Botany 50.

52. **I.** Systematic Mycology. — For juniors; seniors may elect. Morphology and development of typical species representing the orders and families of fungi; practice in identification, collection and preservation of fungi; study of systems of classification; collateral reading. A prerequisite of the senior course in plant pathology, but open to all.

1 class hour. 2 2-hour laboratory periods, credit, 3.

Assistant Professor Davis.

Prerequisite, Botany 26.

53. **II.** Systematic Mycology. — For juniors; seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Davis.
Prerequisite, Botany 52.

54. **III.** Systematic Mycology. — For juniors; seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Davis.
Prerequisite, Botany 53.

55. **I.** Plant Histology. — For juniors; seniors may elect. Comparative study of the tissues of plants; training in histological methods, including the use of precision microtomes, methods of killing, fixing, sectioning, staining and mounting; collateral reading and conferences. This course offers valuable training in preparation for further work in botany.
3 2-hour laboratory periods, credit, 3.
Professor Osmun and Assistant Professor McLaughlin.
Prerequisites, Botany 3 and 25.

56. **II.** Plant Histology. — For juniors; seniors may elect. As stated under Course 55.
3 2-hour laboratory periods, credit, 3.
Professors Osmun and McLaughlin.
Prerequisite, Botany 55.

58. **I.** Systematic Botany of the Higher Plants. — For juniors; seniors may elect. An intensive study of gymnosperms and angiosperms. Lectures deal with the interrelations of the flowering plants and with their ecology, distribution and economic importance. Laboratory work consists of a critical study of types from the most important natural plant families. Particular emphasis is laid on the flora of Massachusetts. The department herbarium and greenhouses supply material of important tropical forms for study.
2 class hours. 2 2-hour laboratory periods, credit, 4.
Assistant Professor Torrey.

59. **II.** For juniors; seniors may elect. As stated under Course 58.
2 class hours. 2 2-hour laboratory periods, credit, 4.
Assistant Professor Torrey.

75. **I.** Plant Pathology. — Seniors. Comprehensive study of diseases of plants; training in laboratory methods and technique, including culture work and artificial inoculation of hosts; miscellaneous diagnosis; study of literature and representative life histories of pathogens. Prepares for civil service, experiment station and college work.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professors Osmun and Davis.
Prerequisite, Botany 54.

76. **II.** Plant Pathology. — Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professors Osmun and Davis.

Prerequisite, Botany 75.

77. **III.** Plant Pathology. — Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professors Osmun and Davis.

Prerequisite, Botany 76.

78. **I.** Plant Physiology. — Seniors. Study of the factors and conditions of (*a*) Plant Nutrition, including the taking up of water and mineral substances, the assimilation of carbon and nitrogen, and the release of energy due to the processes of dissimilation; (*b*) Plant Growth, including the influence of internal and external factors on growth, the development of reproductive and vegetative organs, and touching on plant inheritance and the origin of new varieties; (*c*) Plant Movements, including those due to the taking up of water, and those movements of both motile and fixed forms in response to external stimuli. Special emphasis is laid on the development of skill in the manipulation of apparatus in the laboratory; weekly conferences are held at which students report on assignments.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.

Prerequisites, Botany 26 and Chemistry 51.

79. **II.** Plant Physiology. — Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.

Prerequisite, Botany 78.

80. **III.** Plant Physiology. — Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.

Prerequisite, Botany 79.

82. **II.** Cytology and Embryology. — Seniors. Morphology and physiology of the cell; cell-division; embryonal development.
3 2-hour laboratory periods, credit, 3.
Assistant Professor McLaughlin.

Prerequisites, Botany 26 and 55.

83. **III.** Cytology and Embryology. — Seniors. As stated under Course 82.
3 2-hour laboratory periods, credit, 3.
Assistant Professor McLaughlin.

Prerequisite, Botany 82.

86. **I.** 87. **II.** 88. **III.** Seminar. — For seniors and graduate students. Presentation and discussion of important current botanical papers. A major requirement.
1 class hour. Credit, 1.
The Department.

General and Agricultural Chemistry.

Professor Lindsey, Professor Wellington, Professor Chamberlain, Professor Peters, Assistant Professor Serex.

In teaching the courses in chemistry, emphasis is laid on both their educational and their vocational value. The courses in the freshman year deal with fundamental principles, and give the student such an understanding of the subject as will enable him to apply it in farm practice. The more advanced courses, including quantitative analysis and organic, physiological and physical chemistry, are for those who intend to become teachers and workers in the allied sciences, or who desire to follow agricultural chemistry as a vocation. Advanced training is given by means of postgraduate courses (see Graduate School).

Those completing the undergraduate courses are fitted for positions in the agricultural industries, — fertilizer, feed and insecticide manufacture, — as well as in other lines of industry, and in the State experiment stations and in commercial laboratories. Postgraduate students are prepared for positions as teachers in high schools and colleges, and for more advanced positions in industry and in the experiment stations.

The laboratory, which for many years was used for the work of the Department of Chemistry, was burned early in September, 1922. A new laboratory, to cost $300,000, is under construction and will be ready for occupancy about Jan. 1, 1924. The plans for the new building have been developed with the utmost care, and will provide a building amply suited for the adequate instruction of students in this subject.

Required Courses.

The freshman work consists of two distinct parts: Courses 1 and 2 contain more hours and are for those who have had no chemistry in the secondary schools, and Courses 4 and 5 are for those who have presented chemistry for entrance. Both groups of courses bring the student out at the same point. It is obviously to the advantage of the student to take a course in chemistry in high school and thus obviate the extra hours of Courses 1 and 2 in the freshman year.

1. **I.** General Chemistry. — Freshmen. This course is for those students who do not present chemistry for entrance and who begin the subject in college. An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements and their compounds.
2 class hours. 2 2-hour laboratory periods, 6 study hours, credit, 12.
Professor Peters.

2. **II.** Agricultural Chemistry. — Freshmen. The preparation of a number of substances important in agriculture, such as superphosphate, ammonium sulfate, muriate and sulfate of potash, Paris green, arsenate of lead, Bordeaux mixture, lime-sulfur and emulsions. These materials are prepared in the laboratory and studied in detail in the classroom; some of the substances prepared may be analyzed. Particular attention will be given to

a study of the composition, properties and reactions of soils. Approximate quantitative determinations of a number of constituents of soils and fertilizers will be made.

3 class hours. 2 2-hour laboratory periods, 8 study hours, credit, 15.
Professor PETERS.

4. **I.** ADVANCED GENERAL CHEMISTRY. — Freshmen. A review of the fundamental chemical laws, together with the common acid and base-forming elements and their compounds. Textbook, Kahlenberg's "Outlines of Chemistry." The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate, superphosphate, muriate and sulfate of potash, arsenate of lead, Paris green, Bordeaux mixture, lime-sulfur and emulsions.

2 class hours. 1 2-hour laboratory period, 5 study hours, credit, 9.
Assistant Professor SEREX.

Prerequisite, Entrance Chemistry.

5. **II.** INORGANIC AGRICULTURAL CHEMISTRY. — Freshmen. A study of the chemical composition, properties and reactions of soils, fertilizers, fungicides and insecticides. The laboratory work is divided into three parts: (*a*) qualitative examination of soil, plant ash and superphosphate; (*b*) approximate quantitative determination of moisture, ash, carbonic acid, phosphoric acid, potash, etc.; (*c*) special work on retention of salts by soil, leaching of lime from the soil by carbonated water, etc.

2 class hours. 1 2-hour laboratory period, 5 study hours, credit, 9.
Assistant Professor SEREX.

Elective Courses.

25. **I.** QUALITATIVE ANALYSIS. — *Basic.* — Sophomores. The systematic analysis of metallic salts, presented from the ionic viewpoint. A close study of the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Medicus' "Qualitative Analysis," with Stieglitz's "Qualitative Analysis" and Gooch & Browning's "Qualitative Analysis" for reference. This course should be taken by all intending to follow chemistry as a vocation.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor SEREX.

Prerequisite, Chemistry 2 or 5.

26. **II.** QUALITATIVE ANALYSIS. — *Acidic.* — Sophomores. A continuation of Course 25.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor SEREX.

27. **III.** QUANTITATIVE ANALYSIS. — For sophomores; juniors and seniors may elect. Includes the gravimetric and volumetric determinations of some of the commoner metals and non-metals. Talbot's "Quantitative Chemical Analysis" is used as a text.

1 class hour. 2 4-hour laboratory periods, credit, 5.
Professors WELLINGTON and PETERS.

Prerequisite, Chemistry 25. Course 26 is prerequisite for those majoring in chemistry.

30. **III.** Organic Agricultural Chemistry. — Elective for sophomores, juniors and seniors who have not taken Course 6. Embraces the study of the most important groups of organic compounds of plants and animals, the composition of plants, the chemistry of plant growth, plants as food and as industrial material, the composition of animals, the chemistry of digestion, also the study of some of the products related to plants and animals, such as milk, butter, cheese, sugar and alcohol. The treatment of the subject is general, avoiding (so far as possible) complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the general chemistry of plants and animals and agricultural processes and products.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Chamberlain.

51. **I.** Organic Chemistry. — For juniors; seniors may elect. Consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates and proteins. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and is especially planned for those majoring in chemistry or the other sciences. Those electing Course 51 are expected to elect Course 52.
5 class hours. 2 3-hour laboratory periods, credit, 8.
Professor Chamberlain.
Prerequisites, Chemistry 2 or 5, and Chemistry 27 for those majoring in chemistry.

52. **II.** Organic Chemistry. — For juniors; seniors may elect. A continuation of Course 51, dealing principally with compounds of the benzene series.
5 class hours. 2 3-hour laboratory periods, credit, 8.
Professor Chamberlain.

62. **III.** Advanced Quantitative Analysis. — For juniors; seniors may elect. Advanced work on subjects as stated under Course 27, together with the analysis of insecticides or the analysis of soils and fertilizers.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professors Wellington and Peters.
Prerequisite, Chemistry 27.

65. **III.** Physical Chemistry. — For juniors; seniors may elect. A résumé of general chemistry from the viewpoint of physical chemistry, and the application of physical chemistry to agricultural chemistry.
3 class hours. 1 4-hour laboratory period, credit, 5.
Assistant Professor Serex.
Prerequisite, Chemistry 27.

76. **I.** Milk and Butter Analysis. — For seniors; juniors may elect. A study of milk and butter analytically.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor Peters.
Prerequisite, Chemistry 27.

77. **II.** Cattle Feed, Water and Miscellaneous Analysis. — For seniors; juniors may elect. The analysis of cattle feeds and water, with interpretations. Other materials may be analyzed.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor Peters.

Prerequisite, Chemistry 27.

80. **I.** Physiological Chemistry. — Seniors. Supplementary to Courses 51 and 52. To those who expect to take up scientific work in microbiology, botany, agronomy, animal husbandry, etc., and who have had Courses 51 and 52, it gives acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 51 and 52 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Chamberlain.

86. **II.** Review of General Chemistry. — Seniors. Primarily for students majoring in chemistry; others may elect by permission from the instructor. A knowledge of physical chemistry is desirable. The review of general chemistry is largely theoretical, using Alexander Smith's "Introduction to Inorganic Chemistry" as text.
3 class hours. Credit, 3.
Professor Peters.

87. **III.** History of Chemistry. — Seniors. An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at greater length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course.
3 class hours. Credit, 3.
Professor Wellington.

91. **III.** Special Work in Agricultural Chemical Analysis. — Seniors. The student is given a problem to solve either in analytical chemistry or related to the agricultural industries. This is to acquaint him with the methods used in research and with the literature, and show him how to handle problems in this field of chemistry when occasion arises.
10 laboratory hours, credit, 5.
Professor Peters.

92. **II.** Special Work in Physiological and Organic Agricultural Chemistry. — Seniors. In this course, as in Courses 91 to 95, the student may give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present

themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, dyes, digestion and dietary studies, the chemical study of dairy products, etc.

6 or 10 laboratory hours, credit, 3 or 5.
Professor CHAMBERLAIN.

Prerequisites, Chemistry 51, 52 and 80.

93. **III.** SPECIAL WORK IN PHYSIOLOGICAL AND ORGANIC AGRICULTURAL CHEMISTRY. — Seniors. As stated under Course 92.

10 laboratory hours, credit, 5.
Professor CHAMBERLAIN.

Prerequisite, Chemistry 92.

94. **II.** SPECIAL WORK IN PHYSICAL CHEMISTRY. — Seniors. The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student selects one line of work and follows it through the course, repeating some of the original work.

6 or 10 laboratory hours, credit, 3 or 5.
Assistant Professor SEREX.

Prerequisite, Chemistry 65.

95. **III.** SPECIAL WORK IN PHYSICAL CHEMISTRY. — Seniors. As stated under Course 94.

10 laboratory hours, credit, 5.
Assistant Professor SEREX.

Prerequisite, Chemistry 94.

Entomology.

Professor FERNALD, Professor CRAMPTON, Assistant Professor ALEXANDER, Assistant Professor PHILLIPS.

The introductory Courses 26 and 27, taken together, present a comprehensive view of the relation of insects to man, particularly as crop pests. The most important pests are carefully studied, together with the methods for their control. Courses 50 and 51 are arranged for special study of the pests of any one line of agricultural or horticultural occupation, selected by the student according to his plan of future work, with the intent of making him thoroughly familiar with the pests he will meet in his selected work after graduation, and the means of controlling them. The remaining courses are for the training of men as State or experiment station entomologists; for those going into the care of trees, etc., on estates, or for cities and towns; and as entomological experts, for which the demand has been very large.

Fernald Hall provides excellent lecture rooms and laboratories for this department. The laboratories are provided with individual desks, equipped with microscopes and all needed apparatus of all kinds. Dissecting microscopes, binoculars, microtomes, photographic apparatus, glassware and reagents are available for use and electric light and gas are connected with each desk. Two laboratories, one for juniors and seniors, the other for graduate students, are thus equipped. A department library containing all the more important

works on insects, supplemented by others on the subject in the main library, and by the private libraries of the professors, make available more than 25,000 books and pamphlets on this subject. In addition, all the current magazines are received and their files are accessible to every one. A card catalogue giving references to the published articles on different insects contains about 65,000 cards, and is probably the largest index of its kind in the world. Spray pumps, nozzles and spraying appliances of all kinds are in use in various parts of the courses, and a large collection of insecticides is accessible for study. Photographic rooms are specially prepared for the photography of insects, and the greenhouses, gardens, orchards and the grounds of the college provide wide opportunities for the study, under natural conditions, of insect pests.

Elective Courses.

26. **II.** General and Economic Entomology. — For sophomores; juniors and seniors may elect. For students who desire some knowledge of insects, but who cannot give more than two terms to the subject. Also serves as an introduction to the later courses for those who intend to follow entomology farther. Touches briefly upon the structure of insects so far as this is needed for such a course; deals with metamorphosis, classification to the larger groups, and discusses the most important methods and materials used for control. The greater part of the time is devoted to special study of the most important insect pests, particularly of New England, showing their modes of life, the injuries they cause, and the best methods of control. In this way the most serious pests of fruit trees, ornamental trees and shrubs, market-garden and greenhouse pests, those attacking field crops and those affecting animals and man, are treated. Lectures and recitations. Students taking this course may choose between Courses 27, **III** and 28, **III.**

3 class hours. Credit, 3.

Professor Fernald.

27. **III.** General and Economic Entomology. — A continuation of Course 26. Lectures and recitations, completing the subject.

2 class hours. Credit, 2.

Professor Fernald.

Prerequisite, Entomology 26.

28. **III.** Economic Entomology. — A continuation of Course 26, with field work from about May 1; lectures and recitations till about May 1; two-hour field periods thereafter. In the field the work of insects will be studied and collections of insects made. Methods of collecting, mounting and preparing insects for collections will be taught. Class limited to 30 members.

2 class hours till about May 1; thereafter 2 2-hour field periods. Credit, 2.

Professors Fernald, Crampton, Alexander.

Prerequisite, Entomology 26.

50. **I.** Pests of Special Crops. — For juniors; seniors may elect. For students not majoring in entomology. The laboratory work is largely individual in this term. Accordingly, students majoring in subjects other than entomology, but who desire a more complete knowledge of the insects connected with their own major line of work, can obtain it here. A student major-

ing in floriculture, for example, will devote his laboratory time to a careful study of the insects injuring floricultural crops, learning how to recognize them and their work in their different stages, and the best methods for their control. Courses of this kind are available on the insects attacking field crops, market-garden crops, tree fruits, small fruits, shade trees and shrubs, flowers, forest trees, the domesticated animals, household pests and man. This work may be continued in the winter term also. (See Course 51, **II.**)

3 2-hour laboratory periods, credit, 3.
Professor FERNALD.

Prerequisites, Entomology 26 and 27 or 28.

51. **II.** PESTS OF SPECIAL CROPS. — As stated in Course 50, **I.** For students not majoring in entomology. Those who were not able to take Entomology 50 in the fall may take it here. Those who took Entomology 50 in the fall have an opportunity to continue the work during this term also.

3 2-hour laboratory periods, credit, 3.
Professor FERNALD.

52. **II.** INSECTICIDES AND THEIR APPLICATION. CLASSIFICATION OF INSECTS. — For juniors majoring in entomology. Lectures on the composition, preparation and methods of application of insecticides. Laboratory work on classification of insects, particularly those for which insecticides are used.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professors FERNALD and ALEXANDER.

Prerequisite, Entomology 53.

53. **I.** INSECT MORPHOLOGY. — For juniors majoring in entomology. The lectures treat of the external and internal anatomy of insects, particularly of those characters used in identification, a knowledge of which is needed in the accompanying laboratory work. In the laboratory the external anatomy of the most important groups is studied, followed by the identification of insects of these groups, to show how the characters are made use of in learning the names of insects, and to teach the use of analytical keys.

2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor CRAMPTON.

Prerequisites, Entomology 26 and 27 or 28.

54. **I.** INSECT CLASSIFICATION. — For juniors majoring in entomology. Systematic identification of insects of various groups. Study of various entomological publications and methods of finding the literature on any insect.

3 2-hour laboratory periods, credit, 3.
Assistant Professor ALEXANDER.

Prerequisite, Entomology 53.

56. **II.** PESTS OF SPECIAL CROPS. — For juniors majoring in entomology. Individual laboratory work on the most important insect pests of this country, and the preparation and presentation of bulletin material on them.

3 2-hour laboratory periods, credit, 3.
Professor FERNALD.

55. **III.** Economic Entomology. — For juniors majoring in entomology. Continuation of lectures on insecticides; laboratory work on the identification of insect pests, the relations of insects to disease.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professors Fernald, Crampton and Alexander.
Prerequisites, Entomology 52 and 53.

75. **III.** Forest and Shade-tree Insects. — For juniors; seniors may elect. The lecture work deals with the principles and methods of controlling insects which attack forests and forest products, shade trees, etc. The laboratory periods are devoted to a study of the more important species, their identification, biology and specific control measures. Field work supplements laboratory study if time permits.
1 class hour. 3 2-hour laboratory or field periods, credit, 4.
Assistant Professor Alexander.
Prerequisites, Entomology 26 and 27 or 28; 53 and 54 desirable.

76. **I.** Advanced Entomology. — For seniors. Studies on insect bionomics; scale insects, their structure, habits, methods of mounting, identification, etc.; studies of the animals not insects with which entomologists are expected to deal.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Professors Crampton and Alexander.
Prerequisite, Entomology 55.

77. **II.** Advanced Entomology. — Studies of the life history, habits and methods of control of the important insect pests of the United States; recognition tests of these pests and an examination of the literature on them; methods of bulletin preparation.
3 2-hour laboratory periods, credit, 3.
Assistant Professor Alexander.
Prerequisite, Entomology 76.

78. **III.** Advanced Entomology. — Classification of insects and of their early stages; principles of classification, the use of literature on entomology and the preparation of bibliographies and indices; the enemies of insects.
1 class hour. 3 2-hour laboratory or field periods, credit, 4.
Professors Fernald, Crampton and Alexander.
Prerequisite, Entomology 77.

90. **II.** Evolution. — For juniors; seniors may elect. In order to demonstrate the universal scope and operation of the laws of evolution, the course includes a brief sketch of the probable origin and evolution of matter as viewed in the light of modern physical and chemical research; the evolution of the solar system, leading to the formation of the earth; the changes in the earth, preparatory to the production of life; the physical and chemical basis of life; the probable steps in the formation of living matter, and the theories concerning it; the evolution of living things; the developmental history of man, and of the races of mankind, the evolution of human intelligence, languages, culture, institutions, etc., and man's probable future in the light of his past development. Especial consideration is given to the factors of evolution, the basic principles of heredity, sex-determination, variation and

similar topics, with particular reference to their application to human welfare; and the recent contributions in the field of entomology to the advancement of our knowledge of these fundamental principles are briefly reviewed.
3 class hours. Credit, 3.
Professor CRAMPTON.

Courses in Beekeeping.

65. **III.** INTRODUCTORY BEEKEEPING. — For juniors. A detailed study of the normal behavior of the honey bee and the colony as a whole, followed by a study of such practical work of the apiary as is carried on in spring and summer. In so far as possible the laboratory work parallels the lecture work, and both are made to follow the seasonal processes of the colony. Spring management, swarm control and the production and care of the honey crop are covered thoroughly. The course is designed to meet the needs of the horticulturist as well as those of the honey producer, and should be followed by Course 85, **I.**
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor PHILLIPS.

85. **I.** INTRODUCTORY BEEKEEPING. — For seniors. A continuation of Course 65 and a completion of the beekeeping year. Fall management, preparation for winter and wintering are studied in detail in lectures and laboratory work. It is highly advisable for those taking Course 65 to take Course 85, and thus complete the annual cycle of beekeeping activity.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor PHILLIPS.

86. **II.** ADVANCED BEEKEEPING. — For seniors. A study of the special problems with which the beekeeper deals. The diagnosis and control of the various bee diseases, production of wax, sources of nectar, honey, bee anatomy and physiology, and marketing of the crop are some of the principal topics discussed. The course is designed for those who intend going into honey production either as a principal occupation or as a side line.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor PHILLIPS.

Mathematics and Civil Engineering.

Professor OSTRANDER, Professor MACHMER, Assistant Professor MOORE, Mr. PORTER.

The work of the freshman year is required. It is intended to furnish the necessary drill and groundwork needed for many of the scientific and practical courses of other departments. Thoroughness and accuracy are insisted upon. The advanced work in mathematics is taught from a practical standpoint, and many of its applications to other subjects are given. The courses in surveying and civil engineering are given to furnish the groundwork for a professional career. Special emphasis is given to the subjects bearing on highway construction and maintenance.

For drawing, a room on the north side is used for the draughting. It has draughting tables, T squares, scales, etc., for twenty students. Vernier protractors, parallel rules and steel T squares are available for precise work. A small room is devoted to blue printing.

In surveying, the department has a considerable number of chains and tapes, two railroad compasses, a builder's level, two dumpy levels, two Y levels and two old levels used for teaching the adjustments. Six transits are available for student use. Two are provided with solar attachments. An omnimeter with vernier reading to ten seconds is available for geodetic work. A hand level, mining aneroid barometer, and prismatic compass are provided for reconnoissance work. A set of Gilmore's needles and a Fairbanks' machine are used for cement testing.

Required Courses.

1. **I.** Higher Algebra. — Freshmen. A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, variation, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra."
4 class hours, 8 study hours. Credit, 12.
Professors Machmer, Moore and Mr. Porter.

2. **II.** Higher Algebra. — As stated under Course 1. Required of all who present solid geometry for entrance.
2 class hours, 4 study hours. Credit, 6.
Professors Machmer, Moore and Mr. Porter.

3. **II.** Solid Geometry. — Freshmen. Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Required unless accepted for admission.
2 class hours, 4 study hours. Credit, 6.
Professors Machmer, Moore and Mr. Porter.

4. **II.** Mensuration and Computation. — Freshmen. A review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations; use of slide rule. Also the graph, mensuration of plane and solid figures, weights and measures and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of woodworking; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; computation of areas from simple measurements.
2 class hours, 4 study hours. Credit, 6.
Professor Machmer and Mr. Porter.

5. **III.** Plane Trigonometry. — Freshmen. The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry."
3 class hours, 6 study hours. Credit, 9.
Professors Machmer, Moore and Mr. Porter.

Elective Courses.

26. **II.** Plane Surveying. — For sophomores; juniors and seniors may elect. The elements of the subject, including the adjustment and use of the usual instruments. Textbook and lectures.
2 class hours. Credit, 2.
Professors Ostrander and Moore.

27. **III.** Plane Surveying. — For sophomores; juniors and seniors may elect. As stated under Course 26. Includes field work.
3 2-hour laboratory periods, credit, 3.
Professors Ostrander and Moore.
Prerequisite, Mathematics 26.

50. **I.** Analytic Geometry. — For juniors; seniors may elect. A discussion of the geometry of the line, the circle, conic sections, and the higher plane curves. Fine and Thompson's "Co-ordinate Geometry."
3 class hours. Credit, 3.
Professor Machmer.
Prerequisites, Mathematics 1, 2, 3 and 5.

51. **II.** Differential and Integral Calculus. — For juniors; seniors may elect. A first course in the subject, with some of the more important applications. Granville's "Differential and Integral Calculus."
5 class hours. Credit, 5.
Assistant Professor Moore.
Prerequisites, Mathematics 1, 2, 3 and 5.

52. **III.** Integral Calculus. — For juniors; seniors may elect. A continuation of Course 51.
5 class hours. Credit, 5.
Assistant Professor Moore.
Prerequisite, Mathematics 51.

53. **II.** Elementary Structures. — For juniors; seniors may elect. An elementary course in roofs and bridges. Textbook and lectures.
3 class hours. 1 2-hour laboratory period, credit, 4.
Professor Ostrander.

75. **I.** Hydraulics and Sanitary Engineering. — For seniors; juniors may elect. Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Textbook and lectures.
5 class hours. Credit, 5.
Professor Ostrander.

76. **I.** Materials of Construction, Foundations and Masonry Construction. — For seniors; juniors may elect. Textbook and lectures.
4 class hours. 1 2-hour laboratory period, credit, 5.
Professor Ostrander.

77. **II.** Roads and Railroads. — For seniors; juniors may elect. Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Textbook and lectures.
3 class hours. Credit, 3.
Professor Ostrander.

78. **III.** Roads and Railroads. — For seniors; juniors may elect. As stated under Course 77.
3 2-hour laboratory periods, credit, 3.
Professor Ostrander.

Prerequisite, Mathematics 77.

Microbiology.

Professor Marshall, Assistant Professor Itano, Mr. Avery, Miss Garvey.

Three objectives are sought in the arrangement of the courses following: (1) Introductory courses (50 and 51) needed in the general training of every college student. (2) An introductory course followed by a specific course (as 80, 81, 82, 83), necessary to every student engaged in the Division of Agriculture, with which the specific course deals. (3) Introductory courses (50 and 51) followed by Courses 52, 75, 76 and 81, preparatory for students who are aiming to specialize in agricultural microbiology. (Courses 75, 76 and 81 are adapted to those having Courses 50 and 51 only, and are also adapted to those majoring in microbiology.)

The microbiological work is carried on in a building especially designed for it. There are 4 class laboratory rooms, 8 private laboratory rooms, 1 lecture room, 5 incubator rooms, 3 sterilizing rooms, 3 hood rooms, 3 washing rooms, 3 inoculating rooms, 3 weighing rooms, an animal room, a photographic and a dark room, a sub-basement refrigerator room, a library and 4 office rooms.

The class laboratory rooms are so arranged that individual desks are available for student use. Hot and cold water and gas connections are convenient for each desk; high-pressure steam and electric connections are also available. The building is well lighted and of sanitary construction; all the walls are of brick, and the building is fireproof.

The library is equipped with such books and current periodicals as are useful in the conduct of bacteriological work and investigations. Twenty-four scientific magazines are available regularly.

There are incubators, both electric and gas, hot-air sterilizers, ordinary steam sterilizers, autoclaves, an inspissator, blood-testing apparatus, vacuum apparatus, air-pressure apparatus, shaker, grinder, centrifugal machines, a water still of 5 gallons per hour capacity, Hoskins' combustion furnace, a balopticon, complete microphotographic equipment, microscopes, microtome, and such other apparatus, glassware and chemicals as are needed for extensive and intensive work.

25. **I.** Personal Hygiene. — For sophomores. Such subjects as the hygiene of the mouth and teeth, the gastro-intestinal tract, food, the skin, respiration apparatus, ear, eye and nervous system are reviewed. The value

of bathing, clothing, physical exercise, etc., are considered. Attention is given to emergencies, accidents of "first aid," and such other matters as usually fall within this category.
2 class hours. Credit, 2.
Professor MARSHALL and Miss GARVEY.

In place of Military 25; fall term, sophomores.

26. **II.** For sophomore men. An extension of Course 25.
2 class hours. Credit, 2.
Professor MARSHALL and Miss GARVEY.

In place of Military 26; winter term, sophomores.

27. **III.** SANITARY SCIENCE. — For sophomores. The usual topics of sanitary science, as ventilation, heating, plumbing, water supply, sewage disposal, food control and communicable diseases, are treated from the standpoint of individual and public health control.
2 class hours. Credit, 2.
Professor MARSHALL and Miss GARVEY.

In place of Military 27; spring term, sophomores.

Elective Courses.

50. **I, II** and **III.** INTRODUCTORY AND GENERAL MICROBIOLOGY. — For juniors; seniors may elect. Aims to provide elementary basis for microbial studies and interpretation, to enable students to pursue special pertinent courses which will serve as supports in practical electives or majors, and to furnish students with such material as will be valuable in understanding public health problems.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor MARSHALL and Mr. AVERY.

51. **II** and **III.** MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY. — For juniors; seniors may elect. Types of micro-organisms, technic of handling, methods of culture and functions of micro-organisms are considered. This course is fundamental to all advanced and extended microbiological studies.
10 laboratory hours, credit, 5.
Mr. AVERY.

Prerequisite, Microbiology 50.

52. **III.** ADVANCED MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY. — For juniors; seniors may elect. Prepares for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technique and methods of culture, together with a more extensive knowledge of micro-organisms and their functions.
10 laboratory hours, credit, 5.
Assistant Professor ITANO.

Prerequisites, Microbiology 50 and 51.

75. **II.** Agricultural Microbiology. — For seniors; juniors may elect. This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture, — the microbiological features of air, water, sewage, soil, dairy, fermentations, food, vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control or sanitary and hygienic practices.

10 laboratory hours, credit, 5.
Professors Marshall and Itano, and Mr. Avery.

Prerequisites, Microbiology 50 and 51.

76. **III.** Agricultural Microbiology. — For seniors; juniors may elect. As stated under Course 75.

10 laboratory hours, credit, 5.
Professors Marshall and Itano, and Mr. Avery.

Prerequisites, Microbiology 50 and 75.

80. **II.** Soil Microbiology. — For seniors; juniors may elect. Such subjects as the number and development of micro-organisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention.

10 laboratory hours, credit, 5.
Assistant Professor Itano.

Prerequisites, Microbiology 50 and 51.

81. **I.** Hygienic Microbiology. — For seniors; juniors may elect. An attempt will be made to select certain material which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which micro-organisms enter the body, the influence of body fluids and tissues upon them, body reactions with micro-organisms (susceptibility and immunity); the micro-organisms of some of the most important infectious diseases, methods of control, including disinfectants and disinfection, antiseptics, antisepsis and asepsis, will be treated.

10 laboratory hours, credit, 5.
Assistant Professor Itano.

Prerequisites, Microbiology 50 and 51.

82. **I.** Dairy Microbiology. — For seniors; juniors may elect. Special emphasis is placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease-producing organisms; the value of straining, aeration, clarification, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bacterial content of butter; a passing survey of the microbiology

of cheeses; a study of special dairy products, as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represents a list of topics considered.

10 laboratory hours, credit, 5.
Professor Marshall and Miss Garvey.

Prerequisites, Microbiology 50 and 51.

83. **III.** Food Microbiology. — For seniors; juniors may elect. A study of the principles of food preservation, and food preservation by means of drying, canning, refrigerating and addition of chemicals, will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased and poisonous foods, will receive consideration. Contamination of food supplies by means of water, sewage, handling, exposure, diseased persons, etc., is of especial significance, and will be demonstrated by laboratory exercises. Laboratory inspection of foods is now a subject of great import and is given attention.

10 laboratory hours, credit, 5.
Professor Marshall and Miss Garvey.

Prerequisites, Microbiology 50 and 51.

Physics.

Professor Hasbrouck, Professor Harrington, Mr. Alderman.

The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry and zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.

In Courses 25, 26 and 27 the subject-matter is presented with the idea of its special application primarily in the work in agriculture and general science. The full year's work is advised for all students continuing work specifically in the Division of Science. Courses 25 and 26 are required of all students. The subject-matter is especially selected and arranged for its practical application rather than its theoretical development. Courses 50, 51 and 52 are advised for students in chemistry, general biology, microbiology and general science. The subject-matter is selected, and the courses developed, with the idea of making the student proficient in laboratory manipulation. Sufficient theory is given in connection with the work to enable the student to apply the knowledge and practice thus gained in the departments indicated above.

The department has at its command a building on the east campus, containing a general lecture room and laboratory for sophomore work, a laboratory for junior work, and in the basement one small laboratory for quantitative work in light measurement. There is also in the basement a fairly well-equipped shop for the repair and construction of apparatus used in the department work. The usual apparatus for the demonstration in the lecture room is in the possession of the department.

Required Courses.

25. **I.** General Physics. — Sophomores. Mechanics of solids and fluids. This course includes statics, with equilibrium of rigid bodies, work, energy and friction; kinetics, considering rectilinear motion and motion in a curved path; harmonic motion; rotation of rigid bodies, including kinematics of rotation; liquids and gases, with properties of fluids at rest and in motion; properties of matter and its internal forces, including elasticity, capillarity, surface tension.
3 class hours. 1 2-hour laboratory period, credit, 4.
Professors Hasbrouck and Harrington and Mr. Alderman.

26. **II.** Electricity and Magnetism. — Sophomores. Includes such subject-matter as magnetism, electrostatics, electric currents with their production, chemical, heating and mechanical effects; battery cells, measurement of voltage, current flow and resistance, motors and generators.
3 class hours. 1 2-hour laboratory period, credit, 4.
Professor Harrington and Mr. Alderman.

Elective Courses.

27. **III.** Heat and Light. — For sophomores; juniors and seniors may elect. Thermometry, expansion, colorimetry and specific heat, transmission of heat, changes of state, radiation and absorption. Wave theory of light, optical instruments, analysis of light, color, interference, diffraction, polarization.
3 class hours. 1 2-hour laboratory period, credit, 4.
Professors Hasbrouck and Harrington and Mr. Alderman.

50. **I.** 51. **II.** 52. **III.** Experimental Physics. Mechanics, Sound, Heat, Light, Electricity and Magnetism. — For juniors; seniors may elect. This course consists of a series of physical measurements in the laboratory, accompanied by lectures. The lectures deal chiefly with the methods and principles involved in the laboratory work. High-grade instruments of precision are employed in the laboratory work, and the student is expected to acquire some ability to make accurate observations. The primary object of the course is to develop in the student scientific habits of thinking by direct personal observation of physical phenomena.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Harrington.
Prerequisite, Physics 27 or other science, subject to the approval of the Department.

55. **III.** Analytical Mechanics. — For juniors; seniors may elect. An introduction to the application of the calculus to the mechanics of solids; statics and kinetics of rigid bodies; elasticity; vector analysis. For students who have taken or are taking Mathematics 52.
3 class hours. Credit, 3.
Mr. Alderman.

75. **I.** 76. **II.** 77. **III.** Theory of Light. — For seniors. Propagation of light, formation of optical images, photography, optical instruments, interference, diffraction, spectroscopy, optical phenomena of the atmosphere,

polarization and double refraction, magneto-optics, photo-electricity, radiation, electromagnetic waves, X-rays and crystal structure, electron theory, principle of relativity.

3 class hours. Credit, 3.

Professor HARRINGTON.

Prerequisite, Mathematics 51.

Veterinary Science and Animal Pathology.

Professor GAGE, Assistant Professor LENTZ.

The courses in veterinary science have been arranged to meet the needs (1) of students who propose following practical agriculture; (2) of prospective students of human and veterinary medicine; and (3) of teachers and laboratory workers in the biological sciences.

The department occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There is a lecture hall, a museum, a demonstration room, a photographing room and a workshop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in every department of veterinary science, including pathology, serology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

Elective Courses.

50. **II.** VETERINARY HYGIENE AND STABLE SANITATION. — For juniors; seniors may elect. Familiarizes students with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals.

5 class hours. Credit, 5.

Assistant Professor LENTZ.

75. **I.** COMPARATIVE (VETERINARY) ANATOMY. — For seniors; juniors may elect. The anatomy of the horse is studied in detail, and that of other farm animals, particularly the ox. This course is essential for those students wishing to elect Course 77.

5 class hours. Credit, 5.

Assistant Professor LENTZ.

76. **II.** GENERAL VETERINARY PATHOLOGY. MATERIA MEDICA AND THERAPEUTICS. — For seniors; juniors may elect. Such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, pre-

vention and treatment of disease. The course in pathology is followed by one in materia medica and therapeutics, dealing with the origin, preparation, pharmacology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered.

5 class hours. Credit, 5.

Assistant Professor LENTZ.

77. **III.** APPLIED GENERAL PATHOLOGY. — For seniors; juniors may elect. This course is a continuation of Course 76. Particular attention is given to the etiology, the pathogenesis and the prophylaxis of the communicable and non-communicable diseases of the different species of domesticated animals. Lectures and demonstrations.

5 class hours. Credit, 5.

Assistant Professor LENTZ.

Prerequisites, Veterinary 75 or Veterinary 78, 79 and 80.

78. **I.** ESSENTIALS OF GENERAL PATHOLOGY. — For seniors; juniors may elect. Introduces students to some of the essential anatomical, histological and general physiological phenomena essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis are considered in the laboratory. The various chemical and biological reactions and tests are presented from the standpoint of pure science, showing applications of chemistry and biology. The course serves to educate liberally and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work.

2 3-hour laboratory periods, credit, 3.

Professor GAGE.

79. **II.** ESSENTIALS OF GENERAL ANIMAL PATHOLOGY. — For seniors; juniors may elect. A continuation of Course 78, devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases is prepared for microscopical study. Some of the biological products used in protecting animals against disease are considered.

2 3-hour laboratory periods, credit, 3.

Professor GAGE.

Prerequisite, Veterinary 78.

80. **III.** ESSENTIALS OF GENERAL ANIMAL PATHOLOGY. — For seniors; juniors may elect. As stated in Courses 78 and 79.

2 3-hour laboratory periods, credit, 3.

Professor GAGE.

Prerequisite, Veterinary 79.

85. **I.** AVIAN PATHOLOGY. — For seniors; juniors may elect. A course in poultry diseases. The object is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. Consists of a systematic study of the diseases of the alimentary tract, liver and abdominal

region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites are considered; also diseases of the skin and reproductive organs. Lectures and demonstrations.

2 3-hour laboratory periods, credit, 3.
Professor GAGE.

86. **II.** AVIAN PATHOLOGY. — For seniors; juniors may elect. As stated under Course 85, also devoted to the study of some of the special diseases of poultry. Recent methods used in the control of these diseases are considered and opportunity offered the student for demonstrating various disease processes by means of prepared slides. Lectures, demonstrations and laboratory work.

2 3-hour laboratory periods, credit, 3.
Professor GAGE.

Prerequisite, Veterinary 85.

87. **III.** AVIAN PATHOLOGY. — For seniors; juniors may elect. As stated under Courses 85 and 86.

2 3-hour laboratory periods, credit, 3.
Professor GAGE.

Prerequisite, Veterinary 86.

Zoölogy and Geology.

Professor GORDON, Mr. FOSS.

The facts and principles of the sciences of zoölogy and geology have important applications in industry and the arts, and with those of their sister sciences form a body of knowledge of value and interest with which the educated man finds it necessary to gain a close familiarity. The elective courses in this department stand as offerings to students who wish to supplement their work in other departments, or who, for any reason, wish to enlarge their knowledge in either zoölogy or geology. Students are encouraged to consult the department about any courses which may be available to them, and which might prove necessary or helpful for any line of work they may wish to follow.

The building occupied jointly by the department of entomology and the department of zoölogy and geology has for the work in zoölogy and geology laboratories equipped with gas, compound microscopes and the accessories needed for study, research and demonstration in these subjects. There are two lecture rooms used jointly by the two departments. The Zoölogical Museum has a representative collection of several thousand specimens of animals, and is drawn upon for material illustrating the various courses.

ZOÖLOGY.

Required Course.

25. **I.** GENERAL PRINCIPLES AND TEACHINGS OF ZOÖLOGY. — Sophomores. An introductory course in which some of the basic features of animal structure, functions of organs and relations of animals to each other are emphasized. In the laboratory work an attempt is made to give first-hand knowledge of animals as a means to a better understanding of some modern conceptions that have grown out of zoölogical science, and with which the lectures deal.

2 class hours. 2 2-hour laboratory periods, credit, 4.
The DEPARTMENT.

Elective Courses.

26. **II.** Elements of Mammalian Anatomy. — Sophomores; juniors and seniors may elect. An introductory course which aims to acquaint the student with the positions, relations, names and functions of the principal organs and systems of organs of the mammalian body.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Prerequisite, Zoölogy 25.

50. **I.** Synoptic Invertebrate Zoölogy. — Juniors; seniors may elect. A course in which the student examines and compares representatives of the various phyla, classes and orders of the non-vertebrate animals.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Prerequisite, Zoölogy 25.

51. **II.** Synoptic Invertebrate Zoölogy. — Juniors; seniors may elect. Continuation of Course 50.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Prerequisite, Zoölogy 50.

52. **III.** Synoptic Invertebrate Zoölogy. — Juniors; seniors may elect. Continuation of Course 51.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Prerequisite, Zoölogy 51.

54. **II.** Elements of Microscopic Technique and Histology. — Juniors; seniors may elect. The student is taught the usual methods of preparing material for microscopic examination, including embedding in paraffin and celloidin, sectioning, and differentiation by stains. Supplemented by a microscopic study of selected normal animal tissues in connection with their physiological properties.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

75. **I.** Special Zoölogy. — Juniors, seniors and graduates may apply for such special work as they are qualified to undertake.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

76. **II.** Special Zoölogy. — Same as Course 75.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

77. **III.** Special Zoölogy. — Same as Course 75.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

79. **III.** Ornithology. — A study of the taxonomic characters, distribution and habits of birds.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Geology.

27. **III.** General Geology. — Sophomores; juniors and seniors may elect. A course in the physical aspects of geology, dealing with the origin, arrangement and manifold changes of the materials composing the earth's crust. Excursions by arrangement.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Gordon.

DIVISION OF THE HUMANITIES.

Professor LEWIS.

Economics and Sociology.

Professor PARKER, Professor SIMS.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

The courses in economics and sociology are planned with the purpose of giving the student that knowledge and understanding of the important factors and problems in this field of study and life which every active citizen and educated man ought to have.

Elective Courses.

26. **II.** CIVILIZATIONS, ANCIENT AND MODERN. — For sophomores; others may elect. The evolutionary origin and history of man; characteristics of primitive man, departure from the animal status and beginnings of civilization; origin and development of industries, arts and sciences; the evolution of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern development; characteristic features of the leading civilizations and races of ancient and modern times; beneficial and dangerous factors in American life in view of the history of human civilization.
5 class hours. Credit, 5.
Professor PARKER.

50. **II.** BUSINESS AND INDUSTRY. — For juniors and seniors. The forms, organization, administration and labor problems of business. Methods of organizing, financing and administering corporations and partnerships; forms of business administration, wholesaling, jobbing, retailing, advertising, credits and collections; systems of industrial remuneration for wage earners, co-operation and preserving industrial peace; problems concerned with protective legislation for workmen and employers, sweated industries, prison labor, child labor and industrial education.
5 class hours. Credit, 5.
Professor PARKER.

51. **I.** INTRODUCTION TO ECONOMIC PRINCIPLES AND PROBLEMS. — For juniors. Definitions of economic terms, such as wealth, capital, value, etc.; factors of production, exchange and consumption; principles of economic production, supply and demand, diminishing returns, division of labor, productive organization, concentration of capital and labor, trust and monopoly problems, public control of production and distribution; principles of exchange, theories of value, money and its problems; international trade, tariff and free trade theories, American merchant marine, reciprocity, and trade treaties; forms of income, wages, interest, rent, profits and the forces which govern them; principles of spending, economy, luxury, conservation of indi-

vidual and national resources; principles and agencies for saving, investments, banks, building associations, insurance of all kinds; schemes for social organization; socialism, communism, industrial democracy. Textbook and readings.

5 class hours. Credit, 5.

Professor PARKER.

75. **I.** SOCIAL INSTITUTIONS AND SOCIAL REFORMS. — For seniors; juniors by permission. Social institutions, such as the family, the State, property, religions; and such current problems as eugenics, race suicide, divorce, crime and delinquent classes, prison reform, prevention and treatment of dependents and defectives, poverty, its causes and preventions; constructive modern social reform movements for insurance of wage earners, protection of childhood, assurance of safety, health and play time for all classes. The correctional and charitable institutions of Massachusetts are studied in considerable detail.

5 class hours. Credit, 5.

Professor SIMS.

77. **III.** PUBLIC FINANCE, TAXATION, MONEY AND BANKING. — For seniors. Systems and problems of taxation as they are found in Europe and America; objects for spending public revenue; public debts and methods of organizing them; systems of money and currency problems of America; types, methods and functions of banks; economic and financial crises and depressions in the United States; modern war finance. Readings and lectures.

5 class hours. Credit, 5.

Professor PARKER.

History and Government.

Elective Courses.

50. **III.** GOVERNMENT. — For juniors; seniors may elect. Forms and working methods of the governments of Great Britain, Germany, France, Russia, Switzerland, New Zealand and Canada; historic types and theories of government; forms and methods of Federal, State and local governments in America; progress and problems of democracy and new reform movements in organization and administration; new tendencies towards social legislation and extension of governmental control.

5 class hours. Credit, 5.

Professor PARKER.

54. **I.** MODERN EUROPEAN HISTORY. — Juniors; seniors may elect. The modern history of the principal countries of Europe, especially the great movements and revolutions that developed the nations up to the present generation.

3 class hours. Credit, 3.

Professor PARKER.

79. **II.** EUROPEAN HISTORY SINCE 1870. — For seniors; juniors may elect. The Franco-Prussian War and the formation of the German Empire, the unification of Italy, the Third French Republic, European Expansion in the East, the Russo-Japanese War, and the origin, events and probable results

of the War of 1914. While a continuation of Course 54, this course will be complete in itself, and may be elected by those who have had no history training. Its aim is to provide the basis for an understanding of present-day conditions, and for an intelligent participation in world affairs.

3 class hours. Credit, 3.

Professor PARKER.

Languages and Literature.

Professor LEWIS, Professor PATTERSON, Professor MACKIMMIE, Professor ASHLEY, Assistant Professor PRINCE, Assistant Professor JULIAN, Assistant Professor RAND, Miss GOESSMANN, Mr. THISSELL, Mr. BÖGHOLT.

ENGLISH.

Required Courses.

1. **I.** 2. **II.** 3. **III.** ENGLISH. — Freshmen. Composition. Intended to teach straight thinking, sound structure, clear and correct expression. Lectures, recitations, theme writing and conferences.

2 class hours, 4 study hours. Credit, 6 each term.

Professors PATTERSON, PRINCE, RAND and Mr. BÖGHOLT.

25. **I.** 26. **II.** 27. **III.** ENGLISH. — Sophomores. A general reading course in English literature.

2 class hours each term. Credit, 2 each term.

Professor PATTERSON and Miss GOESSMANN.

Elective Courses in English Language and Literature.

50. **I.** ENGLISH POETRY OF THE ROMANTIC PERIOD (1923–24). — Alternates with course 53. For juniors; seniors may elect. A course in history, appreciation and understanding. Some of the writers studied are Gray, Goldsmith, Burns, Scott, Wordsworth, Coleridge, Byron, Keats and Shelley.

3 class hours. Credit, 3.

Professor PATTERSON.

51. **II.** ENGLISH POETRY IN THE NINETEENTH CENTURY (1922–23). — Alternates with Course 54. For juniors; seniors may elect. In general, this course is like Course 50. Tennyson, Browning, Mrs. Browning, Arnold, Clough, the Rossettis, Morris, Swinburne and others.

3 class hours. Credit, 3.

Professor LEWIS.

57. **III.** ENGLISH POETRY IN THE NINETEENTH CENTURY (1922–23). — Alternates with Course 58. For juniors; seniors may elect. As stated under Course 51.

3 class hours. Credit, 3.

Professor LEWIS.

52. **III.** ENGLISH WRITERS FROM MILTON TO POPE. — For juniors; seniors may elect. A survey course that emphasizes the leading writers, literary currents and the thought of the period. Some of the writers studied are Milton, Dryden, Addison, Swift and Pope.

3 class hours. Credit, 3.

Professor PATTERSON.

53. **I.** English Prose of the Romantic Period (1922–23). — For juniors; seniors may elect. A course in English prose paralleling Course 51. Some of the writers studied are Goldsmith, Coleridge, Lamb, DeQuincey and Hazlitt.
3 class hours. Credit, 3.
Professor Patterson.

54. **II.** English Prose in the Nineteenth Century (1923–24). — For juniors; seniors may elect. Parallels Course 51. Among the writers considered will be Macaulay, Carlyle, Ruskin, Newman and Arnold.
3 class hours. Credit, 3.
Professor Lewis.

58. **III.** English Prose in the Nineteenth Century (1923–24). — For juniors; seniors may elect. As stated under Course 54. Alternates with Course 57.
3 class hours. Credit, 3.
Professor Lewis.

55. **II.** American Literature. — For juniors; seniors may elect. A general survey of literature in America, especially in the nineteenth century, with an introduction to the work of the best known writers, and with especial attention to the relations between national life and history and national thought as expressed in literature. The usual authors — Irving, Cooper, Bryant, Poe, Longfellow, Emerson, Hawthorne, Whittier, Parkman, Lowell, Holmes, Whitman, Lanier — are discussed.
3 class hours. Credit, 3.
Assistant Professor Prince.

56. **III.** American Literature. — For juniors; seniors may elect. As stated under Course 55.
3 class hours. Credit, 3.
Assistant Professor Prince.

Prerequisite, English 55.

60. **I.** The Literature of Rural Life. — For juniors; seniors may elect. A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities.
3 class hours. Credit, 3.
Miss Goessmann.

61. **II.** The Literature of Rural Life. — For juniors; seniors may elect. As stated under Course 60.
3 class hours. Credit, 3.
Miss Goessmann.

Prerequisite, English 60.

75. **III.** Prose Fiction. — The short story or the novel. For seniors; juniors may elect. Readings, reports and discussions.
3 class hours or library equivalents. Credit, 3.

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79. **II.** The Drama. — For seniors; juniors may elect. A cursory survey of early English drama, its origin, forms and meaning, will be followed by a careful study of Shakespeare. Two of his plays are analyzed in detail, and many others read and discussed.
3 class hours. Credit, 3.
Assistant Professor Rand.

80. **III.** The Drama. — For seniors; juniors may elect. Traces the development of modern drama, especial attention being given to plays by Congreve, Goldsmith, Sheridan, Robertson, Jones, Pinero, Fitch, Shaw, Moody and Ibsen.
3 class hours. Credit, 3.
Assistant Professor Rand.

Applied English — Rural Journalism.

The courses in rural journalism have two chief aims: first, to turn the student's attention toward matters of contemporary concern; second, to provide training for students who may wish to enter journalism (especially agricultural or industrial journalism or non-urban newspaper work), or who are preparing for the numerous other vocations in which acquaintance with newspaper practices and requirements is of value. All of the courses afford constant practice in writing. So far as conditions permit, instruction is largely individual.

50. **I.** Advanced Composition. — For juniors; seniors may elect. Advanced work in expository writing based upon specimens by contemporary authors and upon the personal experience of the student. Particular attention is given to organization, diction and style.
3 class hours. Credit, 3.
Assistant Professor Rand.

51. **II.** Advanced Composition. — For juniors; seniors may elect. Work in journalistic and fictional narrative with supplementary reading.
3 class hours. Credit, 3.
Assistant Professor Rand.

52. **III.** Advanced Composition. — For juniors; seniors may elect. The preparation of theses and similar manuscripts along such lines as the students may desire. Clearness and readability are the ends to be attained.
3 class hours. Credit, 3.
Assistant Professor Rand.

53. **I.** 54. **II.** 55. **III.** News-gathering and News-writing. — For juniors; seniors may elect. The foundation aims and conceptions of journalism; reporting. Courses 53, 54 and 55 are suited to students whose vocation may require the popular presentation of technical or other informa-

tion; *e.g.*, extension workers, county agents, agricultural-school instructors, experiment-station editors, survey and other social-service workers, men engaged in sociological or economic investigations, landscape architects and civil and sanitary engineers.

6 laboratory hours or class equivalents, credit, 3.

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77. **I.** 78. **II.** 79. **III.** Editorial Materials and Methods. — For seniors; juniors may elect. Readings, quizzes, reports and personal conferences; reading of daily papers and weekly reviews or rural-life periodicals; writing of editorial articles. Recommended to students who desire practice in discovering the significant aspects of matters of public attention and in effectively expressing comment thereon.

6 laboratory hours or class equivalents, credit, 3.

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80. **I.** 81. **II.** 82. **III.** Advanced Journalistic Practice. — Seniors. Preparation, editing and publication in a newspaper of a rural-life page.

8 or 10 laboratory hours, credits, 4 or 5.

Public Speaking.

Elective Courses.

50. **I.** Argumentation. — For juniors; seniors may elect. Presents the fundamental principles of argumentation as applied to oral and written discourse, and develops in the student power to handle argument convincingly and persuasively. Lectures, discussions of leading questions of the day, practice in brief-drawing and the writing of forensics. The course is recommended for those who desire to enter the intercollegiate debates.

3 class hours. Credit, 3.

Assistant Professor Prince.

Prerequisite, Public Speaking 1, 2 or 3.

51. **II.** Occasional Oratory. — For juniors; seniors may elect. A study of the elements of vocal expression and action; speeches on assigned subjects; prescribed reading; the preparation and delivery of several formal orations. Textbook, Shurter's "The Rhetoric of Oratory." The course is recommended for those who wish to enter the Flint contest.

3 class hours. Credit, 3.

Assistant Professor Prince.

Prerequisite, Public Speaking 1, 2 or 3.

French and Spanish.

Professor Mackimmie, Mr. Thissell.

The aim of the courses in French and Spanish is to give the student a practical knowledge of these languages for the purpose of wider reading and research, to introduce him to some of their treasures in art and science, and through the literature to acquaint him with the people. In the elementary courses as much time as possible is given to oral work, to develop a speaking, as well as a reading, knowledge of the tongue.

French.

Required Courses.

1. **I.** 2. **II.** 3. **III.** Elementary French. — Freshmen; open upon arrangement to other students. The essentials of grammar are rapidly taught and will be accompanied by as much reading as possible. Required of freshmen presenting German for entrance who do not continue that language and have not studied French.
3 class hours, 6 study hours. Credit, 9, **I, II** term.
2 class hours, 4 study hours. Credit, 6, **III** term.
Mr. Thissell.

4. **I.** 5. **II.** 6. **III.** Intermediate French. — Freshmen; open upon arrangement to other students. Training for rapid reading. The reading of a number of short stories, novels and plays; composition, reports on collateral reading from periodicals and scientific texts in the library.
3 class hours, 6 study hours. Credit, 9, **I, II** term.
2 class hours, 4 study hours. Credit, 6, **III** term.
Professor Mackimmie and Mr. Thissell.
Prerequisite, required of freshmen who present two years of French for entrance and do not take German.

Elective Courses.

25. **I.** Intermediate French. — For sophomores; open upon arrangement to other students. Training for rapid reading; the reading of a number of short stories, novels and plays; readings from periodicals and scientific texts in the library.
3 class hours. Credit, 3.
Mr. Thissell.

Prerequisites, French 1, 2 and 3.

26. **II.** Intermediate French. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Mr. Thissell.

Prerequisite, French 25.

27. **III.** Intermediate French. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Mr. Thissell.

Prerequisite, French 26.

28. **I.** Advanced French. — For sophomores; open upon arrangement to other students. A reading course. Balzac's "Eugénie Grandet" and "Le Père Goriot," and other masterpieces of the nineteenth century; Brunetière's "Honoré de Balzac" and Harper's "Masters of French Literature," readings in the library and written reports.
3 class hours. Credit, 3.
Professor Mackimmie.

Prerequisites, French 4, 5 and 6.

29. **II.** Advanced French. — For sophomores; open upon arrangement to other students. As stated under Course 28.
3 class hours. Credit, 3.
Professor Mackimmie.

Prerequisites, French 4, 5 and 6.

30. **III.** Advanced French. — For sophomores; open upon arrangement to other students. General view of the history of French literature; Kastner and Atkins' "History of French Literature." Representative works of the important periods. Outside reading.
3 class hours. Credit, 3.
Professor Mackimmie.

Prerequisites, French 25 and 26, or French 28 and 29.

50. **I.** Scientific French. — For juniors; seniors may elect. Meets the requirements of individual students and equips them with exact English equivalents for the French scientific terms in their particular science. Word lists of scientific terms are required, and also weekly readings and reports from scientific works in the subject in which they are majoring. Several scientific works are read.
3 class hours. Credit, 3.
Mr. Thissell.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

51. **II.** Scientific French. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Mr. Thissell.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

52. **III.** Scientific French. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Mr. Thissell.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

75. **I.** French Literature. — For seniors; juniors may elect. The object of Courses 75, 76 and 77 is to give an introduction to recent movements in French literature. Course 75 deals with the drama, and plays by Augier, A. Dumas *fils*, Delavigne and other contemporary dramatists.
2 class hours. Credit, 2.
Professor Mackimmie.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

76. **II.** French Literature. — For seniors; juniors may elect. The novel. Works by Flaubert, the De Goncourts and Zola are read. Written reports are required on outside reading.
2 class hours. Credit, 2.
Professor Mackimmie.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

77. **III.** French Literature. — For seniors; juniors may elect. Modern criticism. Sainte-Beuve, "Causeries du Lundi" (Harper) and works by Taine and Renan. Reference book, Lanson's "Histoire de la Littérature Française."
2 class hours. Credit, 2.
Professor Mackimmie.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

Spanish.

Elective Courses.

50. **I.** Elementary Spanish. — For juniors; seniors may elect. Open to other students upon arrangement. Grammar, with special drill in pronunciation; exercises in conversation and composition. Reading from a reader and selected short stories.
3 class hours. Credit, 3.
Professor Mackimmie.

51. **II.** Elementary Spanish. — For juniors; open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit, 3.
Professor Mackimmie.
Prerequisite, Spanish 50.

52. **III.** Elementary Spanish. — For juniors; open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit, 3.
Professor Mackimmie.
Prerequisite, Spanish 51.

75. **I.** Modern Spanish Authors. — Seniors. Reading from modern Spanish novel and drama. Translation of English into Spanish. Private reading.
2 class hours. Credit, 2.
Professor Mackimmie.
Prerequisite, Spanish 52.

76. **II.** Modern Spanish Authors. — Seniors. As stated in Course 75.
2 class hours. Credit, 2.
Professor Mackimmie.
Prerequisite, Spanish 75.

77. **III.** Modern Spanish Authors. — Seniors. As stated in Course 75.
2 class hours. Credit, 2.
Professor Mackimmie.
Prerequisite, Spanish 76.

German and Music.

Professor Ashley, Assistant Professor Julian.

German.

The courses in German are intended to give the student a reading knowledge of the language and to introduce to him some of the masterpieces of German literature. To the student interested in pursuing advanced reading in scientific German, opportunity is given to do corollary reading in his major subject, in collaboration with the head of that department.

Required Courses.

1. **I.** 2. **II.** 3. **III.** Elementary German. — Freshmen; open upon arrangement to other students. Grammar, composition and reading. Especial attention is given to oral work in German and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German.
3 class hours, 6 study hours. Credit, 9, **I, II** term.
2 class hours, 4 study hours. Credit, 6, **III** term.
Professors Ashley and Julian.

4. **I.** 5. **II.** 6. **III.** Intermediate German. — Freshmen; open upon arrangement to other students. Selected works of Schiller, Heine and Goethe. Grammar review and advanced prose composition.
3 class hours, 6 study hours. Credit, 9, **I, II** term.
2 class hours, 4 study hours. Credit, 6, **III** term.
Professor Ashley.
Prerequisite, required of freshmen who present two years of German for entrance and do not take French.

Elective Courses.

25. **I.** Intermediate German. — For sophomores; open upon arrangement to other students. Reading of such works as Sudermann's "Frau Sorge," "Wilhelm Tell," "Die Journalisten," etc. Grammar review.
3 class hours. Credit, 3.
Assistant Professor Julian.
Prerequisites, German 1, 2 and 3.

26. **II.** Intermediate German. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Assistant Professor Julian.
Prerequisite, German 25.

27. **III.** Intermediate German. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Assistant Professor Julian.
Prerequisite, German 26.

28. **I.** Advanced German. — For sophomores; open upon arrangement to other students. Reading and studying of Goethe's most important literary productions.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisites, German 4, 5 and 6.

29. **II.** Advanced German. — For sophomores; open upon arrangement to other students. Development of the German novel; rapid reading of great novelists.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisite, German 28.

30. **III.** Advanced German. — For sophomores; open upon arrangement to other students. As stated under Course 29.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisite, German 29.

50. **I.** Scientific German. — For juniors; seniors may elect. Reading in German of modern magazine articles and works of a scientific nature. Different work assigned according to needs of individual students.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisites, German 4, 5 and 6, or German 25, 26 and 27.

51. **II.** Scientific German. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisite, German 50.

52. **III.** Scientific German. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisite, German 51.

75. **I.** German Literature. — Seniors. Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust" and one modern typical drama.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisites, German 28, 29 and 30.

76. **II.** German Literature. — Seniors. As stated under Course 75.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisite, German 75.

77. **III.** German Literature. — Seniors. As stated under Course 75.
3 class hours. Credit, 3.
Professor Ashley.

Prerequisite, German 76.

78. **I.** Conversation and Composition. — For seniors; juniors may elect. Translating connected English into German. Reproducing outside readings in German orally in class.
1 class hour. Credit, 1.
Professor Ashley.

Prerequisites, German 4, 5 and 6, or German 25, 26 and 27.

79. **II.** Conversation and Composition. — For seniors; juniors may elect. As stated under Course 78.
1 class hour. Credit, 1.
Professor Ashley.

Prerequisite, German 78.

80. **III.** Conversation and Composition. — For seniors; juniors may elect. As stated under Course 78.
1 class hour. Credit, 1.
Professor Ashley.

Prerequisite, German 79.

Music.

Elective Courses.

50. **I.** History and Interpretation of Music. — For juniors; seniors may elect. History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school, — Bach, Händel, Haydn, Gluck and Mozart.
1 class hour. Credit, 1.
Professor Ashley.

51. **II.** History and Interpretation of Music. — For juniors; seniors may elect. A continuation of Course 50. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera.
1 class hour. Credit, 1.
Professor Ashley.

52. **III.** History and Interpretation of Music. — For juniors; seniors may elect. The Modern school and Modern composers.
1 class hour. Credit, 1.
Professor Ashley.

DIVISION OF RURAL SOCIAL SCIENCE.

President BUTTERFIELD.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Agricultural Economics.

Professor CANCE, Assistant Professor SAWTELLE, Mr. MAGINNIS, Professor HART.

Instruction in agricultural economics is designed to show that the agricultural industry justifies its existence chiefly as a supplier of food and raw textile materials for human consumption; that agricultural success is measured by production of values rather than by production of volume of agricultural products; that the goal of the farmer is the largest net profit over a long-time period; that agricultural production includes all processes from purchase of seed and fertilizer and preparation of seedbed until the product reaches the consumer, including collection, transportation, storage, financing, packing, handling and selling; that a knowledge of the business of agriculture and agricultural commerce is to-day more necessary than a knowledge of agricultural technique.

The work of this department is conducted by means of lectures, readings and research in both library and field. A catalogue, now containing some 12,000 cards, covering the various phases of agricultural economics, is maintained. The department is also supplied with a large collection of maps, charts and statistical reports on the prices and supply of agricultural products. A goodly number of regular reports of the Bureau of Markets and other divisions of the United States Department of Agriculture are available for the use of students. Two series of bound volumes of bulletins are kept in the department offices, with duplicate series in the college library; one series already contains 12 volumes on "Co-operation in Agriculture," and the other, 15 volumes on "Marketing of Farm Products."

Required Course.

26. **II.** AGRICULTURAL INDUSTRY AND RESOURCES. — Sophomores. A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States are studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions.
4 class hours. 1 2-hour laboratory period, credit, 5.
Mr. MAGINNIS and PROFESSOR CANCE.

Elective Courses.

50. **I.** ELEMENTS OF AGRICULTURAL ECONOMICS. — For juniors; seniors may elect. Designed to accompany or follow the course in elements of economics. Deals with the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends;

the economic elements in the production and distribution of agricultural wealth; means of exchange; principles of rural credit; problems of land tenure and land values; taxation of farm property; and the maintenance of the economic status of the farmer. Lectures, text, readings, topics and field work.
5 class hours. Credit, 5.
Professor Cance.

51. **III.** Historical and Comparative Agriculture. — For juniors; seniors may elect. A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on the development of agriculture in New England. An attempt is made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Students in education and rural journalism should find this course helpful.
5 class hours. Credit, 5.
Assistant Professor Sawtelle.

52. **II.** Co-operation in Agriculture. — For juniors; seniors may elect. The history, principles and business relations of agricultural co-operation. (1) A survey of the development, methods and economic results of farmers' organizations and great co-operative movements; (2) the business organization of agriculture abroad, and the present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, practical working plans for co-operative associations, with particular reference to credit and purchase and the marketing of perishable products. Lectures, text, assigned readings and practical exercises.
5 class hours. Credit, 5.
Professors Cance and Sawtelle.

53. **III.** The Agricultural Market. — For juniors; seniors and graduate students may elect. A study of the forces and conditions which determine the prices of farm products and the mechanism, methods and problems concerned with transporting, storing and distributing them. Supply and demand, course of prices, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market and direct sales are taken up. The characteristics and possibilities of the New England market are given special attention. Lectures, readings, assigned studies and field work.
5 class hours. Credit, 5.
Professor Cance.

75. **II.** Rural and Business Law. — For seniors; juniors may elect. Land, titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures and class discussions.
5 class hours. Credit, 5.
Professor Hart.

76. **II.** Transportation of Agricultural Products. — For seniors and graduate students; juniors may elect. The development of highway, waterway and railway transportation and its relation to the agricultural development of the country; the principles governing the operation and control of transportation agencies; present-day problems relating to the shipment of farm products, rates, facilities and services; methods of reducing wastes in transportation; the economics of the good roads movement and of motor transportation. Lectures, text and field work.

5 class hours. Credit, 5.

Professors Cance and Sawtelle.

77. **I.** Problems in Agricultural Economics. — For seniors and graduate students; juniors may elect. An advanced course for those desirous of studying more intensively some of the economic problems affecting the farmer, such as: land problems, — land tenure, size of farms, causes affecting land values, private property in land, taxation of farm property; special problems, — cost of producing farm products, farm labor in New England, immigration, agricultural credit. Opportunity is given, if practicable, for field work, and students are encouraged to pursue lines of individual interest.

5 class hours. Credit, 5.

Professor Cance.

78. **III.** Agricultural Credit Facilities. — For seniors and juniors. Lectures, discussions and assigned readings on credit needs of farmers; the legitimate use of credit in the acquisition of land, and the production, storage and marketing of agricultural products; the development of national and State rural credit institutions and laws; the powers and methods of operation of credit institutions with reference to the supply of credit for agricultural purposes; the methods by which the individual may increase his credit standing and borrowing power; ways in which the present credit facilities may be increased.

3 class hours. Credit, 3.

Assistant Professor Sawtelle.

79. **I.** Agricultural Statistics. — For seniors, juniors and graduate students. The nature and sources of agricultural statistics, the methods of obtaining numerical facts, of analyzing and drawing conclusions from statistical data, and the methods of presenting in a true and forceful manner the statistical facts of the agricultural industry. Opportunity is given in the laboratory for practice in the use of statistical methods and processes, and to acquire experience in dealing with practical statistical problems. The application of statistics and statistical methods in the fields of agricultural economics, extension work, education, journalism and the business matters connected with farm operation is emphasized.

2 class hours. 3 2-hour laboratory periods, credit, 5.

Assistant Professor Sawtelle.

80. **I.** Seminar. — For seniors and graduate students. Research in agricultural economics and history; problems of New England agriculture. Library work and reports. If desirable some other topic may be substituted.

For the year 1922–1923, Seminars 80, 81 and 82 will be concerned, in the main, with salesmanship and advertising of agricultural products. Hours to be arranged.

1 2-hour conference period, credit, 2.
The DEPARTMENT.

81. **II.** SEMINAR. — For seniors and graduate students. As stated in Course 80.

1 2-hour conference period, credit, 1 or 2.
The DEPARTMENT.

82. **III.** SEMINAR. — For seniors and graduate students. As stated in Course 80.

1 2-hour conference period, credit, 1 or 2.
The DEPARTMENT.

85. **II.** AGRICULTURAL PRICES. — For seniors and graduate students. A study of the prices of agricultural products and other commodities which are of importance in the agricultural industry. Limited to five students.

2 or 3 2-hour laboratory periods, credit, 2 or 3.
Assistant Professor SAWTELLE.

86. **III.** AGRICULTURAL PRICES. — For seniors and graduate students as stated in Course 85. Limited to five students.

2 or 3 2-hour laboratory periods, credit, 2 or 3.
Assistant Professor SAWTELLE.

Agricultural Education.

Professor HART, Professor WELLES, Mr. HEALD,[1] Miss HAMLIN.

The primary aim of the department is training students for service in some form of educational work. This service may be in one or more of several fields. Teaching is the most common, and includes vocational agriculture. Students contemplating preparation for State approval should confer as early as possible with the head of the department, to the end that they may secure a proper distribution of subjects and properly utilize vacations in acquiring the necessary farm practice. This department also serves as the avenue for recommending graduates to the State Department of Education for teaching positions, including such positions as require the State teachers' certificate.

The equipment includes a combination classroom and laboratory furnished with such articles as seem advisable for the effective work of a high school department of agriculture. This room represents to teachers in training the usable things for their work in a school department. The office of the department is equipped with books and pamphlets on agricultural education properly catalogued.

CO-OPERATION BETWEEN THE STATE DEPARTMENT AND THE COLLEGE.

Under an agreement with the Division of Vocational Education of the State Department of Education, the department of agricultural education is the co-operating agency at the college for the training of teachers of agriculture and other related subjects.

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[1] Representing the State Department of Education in the administration of vocational education acts.

Required Course.

26. **II.** Agricultural Opportunities for Women. — For sophomores. Designed to show the woman who is interested in agriculture what opportunities there are for her in that field, and how she may best take advantage of them. The types of agricultural work for which women are best adapted are discussed. A study is made of some of the special problems which confront the woman farmer, and her best ways of solving them.
2 class hours. Credit, 2.
Miss Hamlin.

Elective Courses.

50. **I.** Educational Psychology. — A basic course for students looking forward to work in education, economics and sociology. The first part of the term is devoted to a study of the general notions of mental life and the explanation of psychological terms used in mental science; the anatomy and physiology of the nervous system and its relation to mental phenomena; and the fields of human activity in which psychology plays an important part. During the latter part of the term students are permitted to choose themes for the purpose of special study. These may be the psychology of teaching; the psychology of management; the psychology of crowds and other aspects of sociology; or the psychology of advertising, salesmanship or other phases of economics.
5 class hours. Credit, 5.
Professor Hart.

51. **I** and **II.** Principles and Methods of Teaching. — For juniors; seniors may elect. Intended primarily for students expecting to teach. Others should consult the department before registering. Includes a study of the laws of learning, exhaustive inquiry into the meaning of interest, apperception, memory-images, judging and reasoning, and their applications in teaching processes; class management and the organization of lesson plans.
5 class hours. Credit, 5.
Professor Welles.

52. **III.** History and Philosophy of Education. — For juniors; seniors may elect. A study of educational history in modern times, educational movements in the United States and their bearing on national aims and ideals, with special emphasis on education for a democracy.
5 class hours. Credit, 5.
Professor Hart.

75. **II.** Organization and Supervision of Secondary Education. — For seniors; juniors may elect. School systems, courses of study, training of teachers, financial support, recent tendencies and policies in secondary and junior high schools.
3 class hours. Credit, 3.
Professor Welles.

76. **I** and **III.** Special Methods in teaching Vocational Agriculture. — For seniors; juniors and others qualified may elect. Students must consult the head of the department or the professor in charge before registering for this course. Work consists of outlining lessons and projects for

the teaching of agriculture or related subjects in agricultural schools or departments; the application of principles of vocational education as embodied in the Smith-Hughes Act and other legislation relative to agricultural education; the necessary adjustments relating to the school, community and administrative officials.
3 class hours. Credit, 3.
Professor Welles.

77. **III.** Extension Organization. Extension Teaching and Boys' and Girls' Club Leadership. — For seniors, juniors and others if after consultation they are deemed qualified. A survey of the development of the demonstration work among and by farmers and in farm homes; the growth, significance and methods of conducting Boys' and Girls' Clubs; the current organization of County, State and Federal Extension Service and Farm Bureaus. A study of the psychology of teaching, involving the theory and practice of visual instruction. Observation and study of the functions of the Extension staff, including both office and field work. Actual practice, so far as possible, in supervising club work, directing or carrying on demonstration projects. The course will be conducted jointly by members of the Extension staff and the staff of the Department of Agricultural Education.
2 class hours. 3 2-hour laboratory periods, credit, 5.
The Department and the Extension Service.

80. **I, II, III** and **IV.** Supervised Teaching. — For seniors and graduate students. Supervised teaching (*a*) in county agricultural schools or high school departments of agriculture under the direction of the State Department of Education and the college department of agricultural education in accordance with a joint agreement; or (*b*) under the supervision of this department only. Besides teaching, the student is required to pursue a course of professional study bearing upon the subject taught, to arrange the subject-matter for lessons, and to outline teaching projects. The number of credits depends upon the number, character and length of teaching exercises and conferences. Scheduled by arrangement.

Under certain conditions a student may absent himself from college during one term of his senior year for supervised teaching. For detailed information regarding this matter consult the department.

Credits, 1 to 5.
Professor Welles.

90. **III.** Genetic Psychology. — For seniors; juniors may elect. A study of the physical and mental growth and development of the individual from birth to maturity; a comparative study of the physiological and mental ages of children; and mental tests.
3 class hours. Credit, 3.
Professor Hart.

91. **I.** Rural Education. — For graduates; seniors may elect. A study of the development of the rural school; its organization and administration; its function for the community and for the individual; its place in the State system; some local surveys.
3 class hours. Credit, 3.
Professor Hart.

Rural Sociology.

Professor Phelan, President Butterfield, Professor Sims, Mr. Novitski.[1]

The courses in rural sociology are designed for two purposes: first, to give students an appreciation of the general problems of country life; second, to afford a definite training for students who wish to take up some specific form of social service. In the last ten years rural sociology has been introduced as a subject into more than 50 per cent of the agricultural schools and colleges. There is a good demand for teachers, and an increasing opportunity in other directions in this subject. The courses afford the student an opportunity to pursue graduate as well as undergraduate work. The library of the college is unusually well equipped with rural sociological material.

Required Course.

27. **III.** Elements of Rural Sociology. — Sophomores. A broad survey of the field of rural sociology, including such topics as the origin of rural sociology, its methods and problems; relation of sociological to the scientific and technical aspects of agricultural problems; the development of the rural community in New England and the west, religious, educational and social ideals of rural people; characteristics and influence of the rural environment, the movement of the rural population, the effects of immigration; rural institutions, the school, the church, local government, effects of modern conditions of life on rural institutions; rural organization; problems of progress, and analysis of the needs of rural life in its further development. Lectures, readings and essays on assigned topics.
3 class hours. Credit, 3.
Professor Sims.

Elective Courses.

50. **I.** Social Condition of Rural People. — For juniors; seniors may elect. A. The rural status: composition of the rural population, nature, extent and causes of diseases and accidents, health agencies of control; extent and causes of rural delinquency and dependency, conditions of temperance, of morality and family integrity; child labor, women's work and position; standard of living, size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics.

B. Rural social psychology: characteristics of the rural mind, character of hereditary and environmental influence; nature and effect of face-to-face groups; fashion, conventionality, custom, character of discussion and of public opinion.
3 class hours. Credit, 3.
Professor Sims.

51. **II.** Rural Government. — For juniors; seniors may elect. A general survey of the development of rural government in the United States, origin of the New England town, its influence upon the west, county government, the influence of the farmer in legislation, good roads movement, credit facilities, taxation, boards of agriculture, agricultural colleges and experiment stations in relation to rural welfare; national government; a general survey of political organizations and movements among farmers in the United States

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[1] On leave of absence.

and foreign countries and their influence in shaping legislation; relation of the Department of Agriculture, postal system, the various national commissions and agencies to rural welfare. Lectures, readings, written exercises on assigned topics.

3 class hours. Credit, 3.

Professor SIMS.

52. **III.** RURAL ORGANIZATION. — For juniors; seniors may elect. A study of the organized agencies by which rural communities carry on their various forms of associated life, particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment; principles underlying leadership, qualifications of the paid leader and the lay leader; the field of rural social service, national, State and local, preparation and opportunity for service; rural community building, a study of organized ways and means by which aid is given local communities. The method, scope and history of local, State and national associations formed about some farm product, their influence in forming class consciousness and in shaping agrarian legislation; need of federation. Lectures, readings and essays on assigned topics.

3 class hours. Credit, 3.

President BUTTERFIELD.

76. **I.** FIELD WORK IN RURAL SOCIOLOGY. — For seniors; juniors may elect. Designed to meet the needs of students who wish to do some constructive work in rural social service while still in college. The work is carried on in co-operation with the various college agencies engaged in rural service. Any project for which credit in this course is to be asked must first have the approval of the head of the department.

From 2 to 6 laboratory hours, credits, 1 to 3.

Professor PHELAN.

Prerequisites, Rural Sociology 27 and 52.

77. **II.** RURAL SOCIAL SURVEYS. — For seniors; juniors may elect. A careful study of the theory and function of statistics, the limitations and difficulties in the use of statistics, the interpretation of statistical data, various methods of graphic representation; a study of surveys, kinds and use, method of gaining information, the basis for conclusions, value of information gained. Text and lectures.

3 class hours. Credit, 3.

Professor SIMS.

79. **I.** SEMINAR. — Enrollment is limited to students who have had at least three courses in rural sociology, and to students majoring in the subject.

Credits, 1 to 3.

Professor PHELAN.

80. **II.** SEMINAR. — Enrollment is limited to students who have had at least three courses in rural sociology, and to students majoring in the subject.

Credits, 1 to 3.

Professor PHELAN.

81. **III.** Seminar. — Enrollment is limited to students who have had at least three courses in rural sociology, and to students majoring in the subject.

Credits, 1 to 3.

Professor Phelan.

Rural Home Life.

Miss Skinner, Miss Bartley.

The Department of Rural Home Life offers elective courses for students majoring in other departments of the college. Fundamentally this training is such as will help young women to be better prepared to adjust themselves readily to their environment in the home and in the community, and to help them realize their responsibility as good homemakers and as good citizens.

The food laboratory, located in the entomology building, is fitted with individual desks (cabinet form) to hold utensils and materials for each student. Each table is equipped with gas stoves. A storage cabinet is provided with bins for supplies and cupboard space for large utensils and illustrative material. This room is well lighted and pleasant. The clothing laboratory is located in the Adams House. The equipment consists of sewing machines, cabinets, work tables, cutting tables, electric irons, dress forms and a collection of materials illustrating the production of textiles for clothing and household use.

Required Courses.

1. **I.** Introduction to Home Economics. — Freshmen women. Lectures on the history and evolution of the home; social customs and their value in family relationships; healthful and suitable care of the wardrobe; principles of nutrition as applied to the student's life; the student's budget, and the keeping of personal accounts.

2 class hours. Credit, 2.

Miss Skinner.

Elective Courses.

25. **I.** 26. **II.** 27. **III.** Textiles and Clothing. — Sophomores. The selection and purchase of suitable materials, their character, cost and durability. Appropriateness and simplicity in dress. Practical work in hand and machine sewing, drafting and designing of patterns, the care and repair of clothing.

1 lecture. 2 2-hour laboratory periods, credit, 3.

Miss Bartley.

50. **I.** Foods and Cookery. — Juniors. An introduction to the subject of foods in their scientific and economic aspects of selection, preparation and use.

2 class hours. 2 2-hour laboratory periods, credit, 4.

Miss Skinner.

51. **II.** Foods and Cookery. — Juniors. A continuation of Course 50, with stress upon meal planning and serving.

2 class hours. 2 2-hour laboratory periods, credit, 4.

Miss Skinner.

52. **III.** Advanced Food Study. — Juniors. A study of food materials in their relation to the daily dietary of families under various conditions; a consideration of dietary standards as influenced by age, sex and occupation; a comparative study of the nutritive values of usual foods.
2 class hours. 2 2-hour laboratory periods, credit, 4.
Miss Skinner.

75. **I.** 76 **II.** Household Management (1923–24). — Juniors and seniors. The application of the principles of scientific management to the household, and the elements of successful home making. The family income, cost of living, household accounts, the budget and its apportionment. The responsibility of the woman to her family and the community in establishing right standards of living. Given in alternate years.
2 class hours. Credit, 2.
Miss Skinner.

78. **III.** Home Nursing (1923–24). — Juniors and seniors. A study of the care of the family health; simple diseases and their prevention; the care of young children and invalids; first aid to the injured. Given in alternate years.
2 class hours. Credit, 2.
Miss Skinner.

GENERAL DEPARTMENTS.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Military Science and Tactics.

Major Frederick E. Shnyder, Cavalry, U. S. A.; Major Herman Kobbe, Cavalry, U. S. A.; Captain James V. V. Shufelt, Cavalry, U. S. A.; Captain Thomas Brady, Jr., Cavalry, U. S. A.; Technical Sergeant John J. Lee, U. S. A., Retired; Staff Sergeant James A. Warren, Cavalry; and a detachment of enlisted men of the United States Army.

Under act of Congress (July 2, 1862) military instruction under a regular army officer was required in this college of all able-bodied male students. Under act of Congress June 3, 1916, as amended by act of Congress Sept. 8, 1916, there was established at this college in April, 1917, an infantry unit of the Reserve Officers' Training Corps. Following the World War and an act of Congress (July 9, 1918) the Reserve Officers' Training Corps is in operation under the regulation of the War Department, administered by the president of the college and the professor of military science and tactics.

Beginning with the fall term, 1920–21, the infantry unit of the Reserve Officers' Training Corps was converted into a cavalry unit.

The primary object of the Reserve Officers' Training Corps is to provide systematic military training at civil educational institutions, for the ultimate purpose of qualifying selected students of such institutions as reserve officers in the military forces of the United States. It is intended to attain this object during the time the students are pursuing their general or professional studies, with the least practicable interference with their civil careers, by employing methods designed to fit men physically, mentally and morally for pursuits of peace as well as war.

All candidates for a degree in a four-year course must take for two years at least three hours a week of military training.

Students in their junior and senior years, who are approved by the president and the professor of military science and tactics, may take the advanced course if they so elect. The advanced course consists of at least five hours per week and a summer camp of about six weeks during the summer vacation, between the junior and senior years. Students taking this course are paid by the Federal government at a rate to be fixed by the Secretary of War, not to exceed the value of the army ration. The rate now fixed is 40 cents per day, which amounts to about $146 per year. Students graduating in the advanced course are eligible for commissions in the Officers' Reserve Corps, *but are not required to accept such commissions if offered.*

The required uniform is of olive drab woolen cloth, and is furnished for the use of the students by the Federal government without cost. It is worn by all cadets when on military duty. New uniforms are furnished each year.

The course for cavalry units of the Reserve Officers' Training Corps includes theoretical and practical instruction in all phases of cavalry work, so distributed over the four-year college course as to qualify students at the end of the freshman year as privates of cavalry; at the end of the sophomore year as non-commissioned officers of cavalry; and upon graduation as reserve officers. The instruction in this department covers cavalry drill, cavalry weapons, —

i.e., rifle, pistol, saber, automatic rifle and machine gun, — map reading and military sketching, minor tactics, equitation, etc. The course in equitation includes cross country riding and instruction in polo. So far as season and weather permit, instruction is of a practical nature out of doors.

Required Courses.

1. **I.** — Freshmen. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 3.

The Professor of Military Science and Tactics, and Assistants.

2. **II.** — Freshmen. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 3.

The Professor of Military Science and Tactics, and Assistants.

3. **III.** — Freshmen. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 3.

The Professor of Military Science and Tactics, and Assistants.

25. **I.** — Sophomores. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 3.

The Professor of Military Science and Tactics, and Assistants.

26. **II.** — Sophomores. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 3.

The Professor of Military Science and Tactics, and Assistants.

27. **III.** — Sophomores. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 3.

The Professor of Military Science and Tactics, and Assistants.

Elective Courses.

50. **I.** — Juniors. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 5.

The Professor of Military Science and Tactics, and Assistants.

51. **II.** — Juniors. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 5.

The Professor of Military Science and Tactics, and Assistants.

52. **III.** — Juniors. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 5.

The Professor of Military Science and Tactics, and Assistants.

75. **I.** — Seniors. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 5.

The Professor of Military Science and Tactics, and Assistants.

76. **II.** — Seniors. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 5.

The Professor of Military Science and Tactics, and Assistants.

77. **III.** — Seniors. Theoretical and practical instruction in military science and tactics, and lectures on military subjects.

Credit, 5.

The Professor of Military Science and Tactics, and Assistants.

Physical Education and Hygiene.

Professor Hicks, Assistant Professor Gore, Mrs. Hicks, Mr. Grayson, Mr. Collins, Mr. Derby.

The purpose of the courses offered by this department is to provide active exercise and to instruct every student how to care for his health and maintain his physical condition while carrying on his college course.

The equipment consists of the Alumni Athletic Field, which has room for two football fields, a quarter-mile cinder track with a 220 straightaway, and the baseball diamond; and also the old field for class football and baseball, two tennis courts, and the drill hall floor for basket-ball. For several years the drill hall floor was used for class work in gymnastics, but its condition has become so bad that this has been discontinued. During the winter months a hockey rink is provided on the college pond.

[All undergraduate male students are given a physical examination upon entering.]

MEN.

Required Courses.

1. **I.** HYGIENE. — Freshmen. Lectures on personal hygiene.
1 class hour. Credit, 1.
Professor HICKS.

2. **I.** RECREATION. — Freshmen. Outdoor games.
1 laboratory hour, credit, 1.
Mr. COLLINS.

3. **III.** RECREATION. — Freshmen. Outdoor games.
1 laboratory hour, credit, 1.
Mr. GRAYSON.

7. **I.** 8. **II.** 9. **III.** RECREATION. — Military substitute for freshman men.
3 1-hour laboratory periods, credit, 3.
Mr. COLLINS.

25. **I.** RECREATION. — Sophomores. Outdoor games.
1 laboratory hour, credit in third term.
Mr. GRAYSON.

26. **III.** RECREATION. — Sophomores. Outdoor games.
1 laboratory hour, credit for Nos. 25 and 26, 1.
Mr. GRAYSON.

30. **I.** 31. **II.** 32. **III.** RECREATION. — Military substitute for sophomore men.
1 2-hour laboratory period, credit, 1.
Professor HICKS.

Elective Course.

77. **III.** TRAINING COURSE. — Seniors. Election by permission only. History of physical education and supervision of athletics.
1 class hour. Credit, 1.
Professor HICKS.

WOMEN.

Required Courses.

4. **I.** RECREATION. — Freshmen. Outdoor games.
3 laboratory hours, credit, 3
Mrs. HICKS.

5. **II.** GYMNASTICS. — Freshmen. Dancing, Swedish games, etc.
3 laboratory hours, credit, 3.
Mrs. HICKS.

6. **III.** RECREATION. — Freshmen. Outdoor games.
3 laboratory hours, credit, 3.
Mrs. HICKS.

27. **I.** Recreation. — Sophomores. Outdoor games.
3 laboratory hours, credit, 1.
Mrs. Hicks.

28. **II.** Gymnastics. — Sophomores. Dancing, Swedish games, etc.
3 laboratory hours, credit, 1.
Mrs. Hicks.

29. **III.** Recreation. — Sophomores. Outdoor games.
3 laboratory hours, credit, 1.
Mrs. Hicks.

Elective Courses.

50. **II.** Gymnastics. — Juniors. Dancing, Swedish games, etc.
3 laboratory hours, credit, 1.
Mrs. Hicks.

76. **II.** Gymnastics. — Seniors. Dancing, Swedish games, etc.
3 laboratory hours, credit, 1.
Mrs. Hicks.

THE LIBRARY.

The general college library consists of all books belonging to the college, including the library of the Experiment Station and all divisional and departmental collections of books. The main collection now occupies the entire building, which was originally intended to serve the purposes of both chapel and library. A dictionary card catalogue is intended ultimately to cover all material in the general college library, which now comprises approximately 70,000 volumes, besides much unbound or paper-bound material, pamphlets, periodicals and newspapers. The library contains also some important special collections of books, amounting to several thousand volumes, not yet catalogued. Much of the constantly increasing pamphlet and periodical material, even though it is not yet comprehended in the general catalogue, is made promptly available by means of check lists, indexes, bibliographies and other library helps. Files of important periodicals make readily accessible to readers the latest contributions to the sum of human knowledge by contemporary leaders in many fields of thought and investigation. Works dealing with the sciences related to the processes and problems of agriculture are in greatest abundance, but literature, history and sociology are also well represented in our collections of books. The reading room is well supplied with encyclopedias and other general reference books, and with current numbers of an attractive list of popular and technical magazines and periodicals.

The greater part of the library material has been recently reclassified and recatalogued in accordance with a standard system, and is thereby rendered at all times directly accessible to teachers and students as well as library workers. From time to time informal lectures on the use of the library will be given to groups of students. By seminar and laboratory methods, individual students will be taught to appreciate books as essential sources of information and culture, and will be instructed in the use of the various devices common in libraries for finding what the library contains. All members of the college community have the privilege of free access to the book stacks for reference purposes, and books not specially reserved may be loaned for extra-library use for a period of two weeks.

The library is open from 8 A.M. to 9.30 P.M. on week days, and from 9 A.M. to 1.30 P.M. on Sundays while college is in session. Shorter hours prevail during vacation.

The Graduate School

THE GRADUATE SCHOOL.

KENYON L. BUTTERFIELD, A.M., LL.D., President of the College.

CHARLES E. MARSHALL, Ph.D., Director of the Graduate School and Professor of Microbiology.

GRADUATE STAFF, 1922–23.

Professor ANDERSON, Professor BEAUMONT, Professor CANCE, Professor CHAMBERLAIN, Assistant Professor CLARK, Professor CRAMPTON, Professor FERNALD, Professor GRAHAM, Professor HART, Assistant Professor ITANO, Professor LINDSEY, Professor OSMUN, Professor PETERS, Professor PHELAN, Professor SALISBURY, Professor SEARS, Professor SHAW, Professor THAYER, Professor TOMPSON, Assistant Professor TORREY, Professor WAUGH, Director MARSHALL, Dean LEWIS, President BUTTERFIELD; Mr. WATTS, Secretary.

This college has provided study of a graduate nature for many years. The need for such training became real when agriculture was recognized as an aggregate of the many sciences involved and the many practices employed. The obsolete notion that agriculture is only farming has been replaced by the notion that farming, as such, is only one element in agriculture. The ramifications and divisions of agriculture are many; most of these call for advanced study and training to meet the exigencies of the times. No apology is, therefore, required for an attempt to fathom the scientific, economic and social intricacies of such a fundamental phase of human effort as agriculture. The value of such an undertaking is, or should be, patent to every intelligent mind familiar with the situation.

Graduate work has been available to students since 1893. At that time it was possible to qualify for the degree of master of science; later, in 1898, for the degree of doctor of philosophy; in 1913, for the professional degrees of master of agriculture and doctor of agriculture; in 1916, for the specific professional degree of master of landscape architecture.

To make the graduate work more effective and distinctive in agriculture, the graduate school was established in 1908. It has become the operating agency for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment station specialists in farm management, dairying, live stock husbandry, poultry science, agronomy, landscape gardening, pomology, vegetable gardening and floriculture; for positions as bacteriologists, botanists, chemists, entomologists; for economists and social workers; and for numerous other positions requiring a great amount of scientific and professional agricultural knowledge, training and experience.

ORGANIZATION.

The school is based upon the department as the unit, and the apprenticeship system as the most effective means of instruction. This gives to the student individuality in treatment and an intimacy with actual conditions of work and operations. The student is assigned to an advisory committee, composed of

the instructor in charge of his major subject as chairman, and instructors in charge of his minor subjects as members, which directs his graduate studies. The chairmen of all these committees together constitute the graduate staff, which controls the policy of the graduate school.

ADMISSION.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.

2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the instructor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for membership in the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

NATURE, METHODS AND REQUIREMENTS OF GRADUATE WORK.

Graduate work differs from undergraduate work in its purposes and methods. The primary aims of the instructor are emphasized in an attempt to have the student adjust himself and place himself in his environment; develop the rule of self-direction and self-instruction; acquire the power of accurate reasoning; gain proficiency and skill in his selected field of study or practice; and obtain an appreciative and discriminative insight into experimentation and original research. Methods are not devised, therefore, for attractiveness, entertainment and superficial reviews, but for the creation of initiative and profound thought, thorough acquaintance with detail, independent advance and industrious habits. Careful readings, lectures, conferences, surveys, laboratory exercises and field work are some of the agencies utilized.

All members of the graduate school are required to attend the course of lectures designed to supplement the technical work of all graduate studies. These lectures will be given once each week, and the students will be held responsible for the work.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major and the others as minors. No two of these subjects may be taken in the same department. An original thesis shall be considered a part of the major subject.

Candidates for the degree of doctor of agriculture are required to select a major and such other subjects as will develop the major in its greatest intensity and comprehensiveness. Successful experience is also requisite, together with a thesis which represents a masterly survey or intimate study through accurate application of some phase of the major subject.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as a major and the other as a minor. These subjects may not be selected in the same department. An original thesis is considered a part of the major subject.

Candidates for the degree of master of agriculture are allowed greater privileges in the selection of subjects, but will be required to select a major and such other supporting lines of study as will be necessary to equip the individual professionally.

Candidates for the degree of master of landscape architecture will be expected to conform to the established courses of the department, and to the requirements of the department in the preparation of a thesis, as well as in actual experience outside the college.

Candidates for membership in the graduate school who do not desire to work for a degree may, with the approval of the director of the school, take more than one subject in the same department, or pursue work in several departments, if their preparation will permit. A statement of the subjects chosen must in each case be submitted to the director of the graduate school for approval. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

The graduate staff reserves the privilege of recommending and allowing courses in other institutions as a part of residence instruction. Such supervision will be exercised and credit granted as are essential to the highest standards of efficiency.

THESES.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject; must show that its writer possesses the ability to carry on constructive study; must be an actual contribution to knowledge; and possess real merit.

The thesis in its final form must be submitted to the director by May 15 of the year in which the student is to present himself for the advanced degree, and before he may take the required examination. Three complete copies are required. One of the copies is to be retained as an official copy by the director, one is to be deposited in the college library, and the third is to be retained by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis.

FINAL EXAMINATIONS.

For the degree of doctor of philosophy or doctor of agriculture, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

For the degree of master of science, master of agriculture or master of landscape architecture, a final examination upon the minor taken is given upon the completion of each course, and in the major a final examination, which may be either written or oral, or both, is given over all the work by the department concerned.

DEGREES CONFERRED.

The degrees of doctor of philosophy and doctor of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years[1] to the prosecution of three subjects of study and research in residence at the college.

2. The earning of not less than one hundred credits in the chief or major subject, and of not less than twenty-five credits in each of two minor subjects.

3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge and accompanied by drawings if necessary. For the degree of doctor of agriculture the thesis may be modified to meet professional requirements.

4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the instructors in charge.

5. A public oral examination.

6. The payment of all fees and college expenses required.

The fee for the degree of master of science, master of agriculture, or master of landscape architecture is $10, and for the degree of doctor of philosophy or doctor of agriculture, $25.

The degrees of master of science, master of agriculture and master of landscape architecture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence. In the case of a master of landscape architecture the student must follow the prescribed course of study.

2. The earning of not less than fifty credits in the chief or major subject, and of not less than twenty-five credits in the minor subject. Students pursuing the course in landscape architecture will devote all of their time to the established course, and meet the conditions of one year of experience outside the college.

3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.

4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

COURSES OFFERED.

Courses available as major subjects for the degree of doctor of philosophy: —

Agricultural Economics.
Botany.
Chemistry.
Entomology.
Horticulture.
Microbiology.
Rural Sociology.

[1] All time statements refer to minimum time.

Courses available as major subjects for the degree of master of science: —

Agricultural Economics.
Agricultural Education.
Agriculture.
Agronomy.
Animal Husbandry.
Botany.
Chemistry.
Entomology.
Horticulture.
Mathematics and Physics.
Microbiology.
Poultry Science.
Rural Sociology.
Veterinary Science.

Courses available as major subjects for the degree of master of agriculture: —

Agronomy.
Animal Husbandry.
Poultry Science.

The course in Landscape Architecture leads to the degree of master of landscape architecture.

Courses available as minor subjects: —

Agricultural Economics.
Agricultural Education.
Agriculture.
Agronomy.
Animal Husbandry.
Animal Pathology.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape Architecture.
Mathematics and Physics.
Microbiology.
Poultry Science.
Rural Sociology.
Zoölogy.

GENERAL OUTLINE OF COURSES FOR ADVANCED DEGREES.

Agricultural Economics.

Major Requirements.

For the Degree of Doctor of Philosophy.

Prerequisite Work. — Candidates must have had the following courses or their equivalents: Economics and Sociology 51, Agricultural Economics 26 and 50.

Required Work. — Candidates must take the following courses: Agricultural Economics 51, 52, 53 and 79. These courses, specially arranged for graduates, may be taken as Courses 120, 170, 155 and 180 for graduate credit. In addition, candidates must take Courses 110, 111, 130, 165 and 175 in Agricultural Economics; Rural Sociology 27 and 50, or equivalent courses; and Economics and Sociology 50 and 77, or equivalent courses.

Each candidate will be required to have a working knowledge of the general field of economics, the history of agricultural economics, the theory of agricultural economics, the problems of agricultural production, land tenure, land problems, agricultural commerce, agricultural co-operation, agricultural credit, statistics of agriculture, and prices, markets and marketing.

For the Degree of Master of Science.

Prerequisite Work. — The same as for the degree of doctor of philosophy.

Required Work. — The same as for the degree of doctor of philosophy, except that there is no language requirement.

GRADUATE COURSES OFFERED.

110. THEORY OF AGRICULTURAL ECONOMICS. — Readings in French, German and English on economics of agriculture. Alternate years, odd, 200 hours. Credits, 3.
Professor CANCE.

111. CURRENT ECONOMIC PROBLEMS AND LITERATURE. — Department seminar throughout the year. Credit, 1 each term.

120. HISTORICAL AND COMPARATIVE AGRICULTURE. — General survey. May be taken in connection with Course 51. Spring term, yearly. Credits, 3.
Assistant Professor SAWTELLE.

121–122. HISTORY OF AMERICAN AGRICULTURE. — Special studies in the history of agricultural institutions, practices or relations. Fall Term, even years. Credits, 5.
ASSISTANT Professor JEFFERSON.

130. PROBLEMS OF AGRICULTURAL PRODUCTION. — The relation of the farmer to the food supply. May be taken in connection with Course 77. Fall term, yearly. Credits, 5.
Professor Cance.

140. LAND TENURE AND THE ACQUISITION OF FARM LAND. — Readings, discussion, original exercises. Alternate years, even. Credits, 3–5.
Professor Cance.

145. FARM LABOR. — Reading and investigation. Credits, 3.
Professor Cance.

150. AGRICULTURAL COMMERCE, INDUSTRY AND TRADE. — A study of trade movements and commercial activities relating to agricultural products. Fall term, alternate years, odd. Credits, 3–5.
Assistant Professor JEFFERSON.

155. THE AGRICULTURAL MARKET. — A study of the forces, methods and institutions of the market for agricultural products. Spring term, yearly. Credits, 5.
Professor Cance.

156. SPECIFIC PROBLEMS IN MARKETING FARM PRODUCTS. — Reports and discussions. Alternate years, odd. Credits, 3.
Professor Cance.

160. AGRICULTURAL PRICES. — Winter term, yearly. Credits, 3.
Assistant Professor SAWTELLE.

161. AGRICULTURAL PRICES. — Spring term, yearly. Credits, 3.
Assistant Professor SAWTELLE.

165. TRANSPORTATION OF AGRICULTURAL PRODUCTS. — Elementary discussion and report. Winter term, yearly. Credits, 5.
Professor CANCE.

166. Specific Transportation Problems. — Original study, reading and report on certain transportation problems related to agriculture. Alternate years, odd. Credits, 3–5.
Assistant Professor Sawtelle.

170. Co-operation in Agriculture. — Elementary problems and discussion. May be taken in connection with Course 50. Winter term, yearly. Credits, 5.
Professor Cance.

171–172. Special Problems in Co-operation for Economic Purposes. — Study, original investigation and discussion. Every third year, beginning 1922. Credits, 3–5.
Professor Cance.

175. Agricultural Credit. — Readings and reports in addition to class lectures on agricultural credit. Taken in connection with Course 78. Spring term, yearly. Credits, 3–5.
Assistant Professor Sawtelle.

180. Elementary Principles of Statistics. — Chiefly related to agriculture. Lectures, laboratory studies and original work. Taken in connection with Course 79. Fall term, yearly. Credits, 5.
Assistant Professor Sawtelle.

181. Specific Problems in Statistics of Agriculture. — Alternate years, even. Credits, 3–5.
Assistant Professor Sawtelle.

185. Rural Law. — Corresponds to Course 78. Spring term, yearly. Credits, 5.
Professor Hart.

186. Studies in Agricultural Legislation. Credits, 3–5.
The Department.

190–195. Investigation of Various Problems related to Agricultural Economics. — Credit given on basis of time spent and reports submitted.

200. Thesis. — Research work in agricultural economics will be developed by four principal methods, namely, historical, statistical, accounting and general field investigation. In all instances mastery of research methods includes facility in investigation, tabulation and interpretation of results.

Agricultural Education.

Major Requirements.

For the Degree of Master of Science.

Prerequisite Work. — A minimum of 25 undergraduate credits distributed among the following lines of study: philosophy, psychology, history of education, principles and methods of teaching, school organization and administration. Graduates of other than agricultural colleges who wish to take their major work in some phase of rural education will be required to

present evidence of a knowledge of rural life and rural industries both scientific and practical. This may involve the study of some undergraduate courses in agriculture or horticulture without graduate credit.

Required Work. — In addition to the regular prescribed work at least a half year of experience in teaching or supervision is required before the candidate is recommended for a degree.

Graduate Courses Offered.

100. History of Agricultural Education. Credits, 1–10.
Professor Hart.

105. Principles and Methods of Teaching Agriculture and Agricultural Science. Credits, 1–20.
Professor Hart.

110. Rural Education: its Organization and Administration.
Credits, 1–20.
Professor Hart.

115. Supervision and Administration of Agricultural Education.
Credits, 1–5.
Professor Hart.

120. Theory of Vocational Education. Credits, 1–10.
Professor Hart.

125. Preparation of Teachers of Agriculture. Credits, 1–10.
Professor Hart.

130. General Educational Theory and Practice. Credits, 1–15.
Professor Hart.

135. Educational Literature. Credits, 1–10.
Professor Hart.

140. Educational Research. Credits, 1–10.
Professor Hart.

200. Thesis. Credits, 25.
Professor Hart.

Minor Requirements.

Minor work is offered in this department for the degrees of doctor of philosophy and master of science. Candidates must have had the equivalent of 15 undergraduate credits in agricultural education, 5 of which must have been in the history of education.

Agronomy.

Major Requirements.

For the Degree of Master of Science.

Prerequisite Work. — Graduate students desirous of taking major work in agronomy should have had good training in the fundamentals of the natural sciences and should have taken undergraduate courses Agronomy 27 and 50, or their equivalents.

Required Work. — Studies will be assigned among courses listed below. Problems may be chosen in which particular attention will be devoted to soils, fertilizers or field crops.

Graduate Courses Offered.

151. Field Crop Production. — (*a*) Varieties. Classification; adaptation to climatic and soil conditions, etc.

(*b*) Distribution as affected by natural and economic conditions.

(*c*) Cultural methods. Early and late planting of the potato seed crop, of silage corn; spacing of plants; keeping qualities as affected by time and methods of harvesting; tillage and moisture control, etc.

(*d*) Storage of cereals, roots and tubers as affected by aeration, temperature, humidity, previous treatment, etc. Credits, 1–25.

175. Soil Technology. — Soil Physics. Textural relationships of soil classes; absorption phenomena; physical properties in relation to mineralogical and chemical properties; soil structure; moisture relationships; the colloidal conditions of soils, etc. Credits, 1–25.

177. Soil Fertility. — (*a*) Soil Chemistry. Nitrogen fertilization, including commercial supply and gain or loss under different systems of soil management; absorption of potash and phosphoric acid; sulfur fertilization; soil acidity, etc.

(*b*) Soil Biology. Fixation of nitrogen by symbiotic and nonsymbiotic organisms; changes of green and animal manures in the soil; ammonification and nitrification; care and preservation of manures; humus in relation to soil fertility, etc. Credits, 1–25.

178. Crop Improvement. — Involves the application of the principles of plant breeding to special crops. Credits, 1–25.

200. Thesis. Credits, 15–25.

Minor Requirements.

Prerequisites are as stated above for major work. In addition, studies suited to the needs of the candidate will be selected from the above courses.

Animal Husbandry.

Major Requirements.

For the Degree of Master of Science or Master of Agriculture.

Prerequisite Work. — Candidate must have had the following courses, or their equivalents, before he can enter graduate work in this department: Animal Husbandry 25, 26, 50, 51, 52, 53, 75 and 78. He should also be able to show evidence of experience in practical animal husbandry.

Required Work. — At least 50 credits must be earned from the following list of courses offered by the department.

Graduate Courses Offered.

100. Historical Studies of Breed Development. Credits, 5–20.

110. Animal Nutrition. Credits, 5–20.

120. Problems in Animal Feeding. Credits, 5–20.

130. Animal Genetics. Credits, 5–20.

140. Problems in Animal Breeding. Credits, 5–20.

200. Thesis. Credits, 15–25.

Minor Requirements.

Minor work in animal husbandry may include undergraduate Courses 50, 51, 53, 81 or 82, and such other work in reading and compilation of material as the instructor may outline. Written examinations will be conducted at the completion of each term's work.

Animal Pathology.

Minor Requirements.

Minor work in animal pathology for the degrees of doctor of philosophy and master of science consists of an especially planned course for graduate students. This is not an undergraduate course, but is arranged to meet the needs of graduate students who have not pursued a course in general pathology. It will continue throughout the year and include reviews in gross and microscopic anatomy, physiological, bacteriological, serological, biochemical and morbid anatomical phases of pathology. Written examinations will be given at the end of each term.

100. General Pathology. — As described above, fall term. Credits, 5.

120. General Pathology. — Continuation of 100, winter term. Credits, 5.

140. General Pathology. — Continuation of 120, spring term. Credits, 5.

160. Biochemical Phases of Pathology. — Second year, fall term. Credits, 5.

180. Pathological Histology. — Second year, winter term. Credits, 5.

Professor Gage.

Botany.

Major Requirements.

For the Degree of Doctor of Philosophy.

Prerequisite Work. — The equivalent of certain undergraduate courses, determined by the department in the case of each student, is prerequisite.

Required Work. — Candidates will be required to take Courses 100 through 107, and 180, 190 and 200. Courses 150 through 155 may be taken for graduate credit in certain cases. The maximum number of major credits which may be earned in this way is thirty-two.

For the Degree of Master of Science.

Prerequisite Work. — The requirements are the same as for the degree of doctor of philosophy.

Required Work. — Candidates will take Courses 100 and 101 and all courses from 102 through 107 which are given during their term of residence, also 180, 190 and 200. In certain cases Courses 150 through 155 may be taken, but not more than 20 credits may be earned in this way.

Graduate Courses Offered.

Courses 100 through 106 are lecture courses. They are given in rotation, except Courses 100 and 101, which come every year.

100. Plant Physiology. — The lectures will consider, under the nutrition of the plant: its chemical structure, absorption of various nutrient substances and their changes in the plant, assimilation and dissimilation of carbon and nitrogen by autotrophic and heterotrophic plants; under changes in the form of plants; growth and form under constant external factors, the influence of variable external and inner factors on growth, form and development; and under plant movements; the various tropisms, nutations, etc. Supplemental demonstrations, laboratory work and readings in the standard texts and journals. One lecture a week for 36 weeks. Credits, 3.

101. Plant Pathology. — A general consideration of the history, nature and causes of plant disease; parasitism, predisposition, immunity, degeneration, natural and artificial infection, dissemination, epidemics, biologic strains, monstrosities and malformations, proliferation, prevention and control, economics of plant diseases. One lecture a week for 36 weeks. Credits, 3.

102. Plant Inheritance. — This course is planned to give the student a comprehensive understanding of the principles and facts of plant inheritance. A study is made of plant variations, Mendel's law of heredity, the physical basis of heredity as established by chromosome behavior, pure lines, mutations, species and graft hybrids, etc. One lecture a week for 12 weeks. Credit, 1.

103. Biologic Relations. — Consideration of certain phases of the morphological and physiological adaptations of plants with regard to insect visit; the rôle of thorns, hairs, tendrils, glands, etc. Various experiments are made to test out experimentally some of the existing theories concerning biologic adaptations. One lecture a week for 12 weeks. Credit, 1.

104. The Ecology of Plants. — This course deals with the water, light and temperature relations of plants, and the various adaptations in response to these factors; the various types of plant formation; the migration of plants; the competition of plants; invasion and successions of plants under varied conditions; and the various types of alternations and zonations. One lecture a week for 12 weeks. Credit, 1.

105. Physiological Plant Pathology. — This course considers those plant diseases not due to bacterial or fungous parasites, but resulting from unfavorable physical or chemical conditions of the soil; from harmful atmospheric influences, such as too dry air, too much moisture, hail, wind, lightning, frost; from injurious gases and liquids; from lack of or too much light; from wounds. A knowledge of the normal physiology of the plant is required. Demonstrations and laboratory work will be given, together with assigned readings. One lecture a week for 12 weeks. Credit, 1.

106. History of Botany. — A historical survey of the science; lives of noted botanists; history of certain culture plants, such as wheat, corn, coffee, potato, rice, and their influence on civilization; reading. One lecture a week for 24 weeks. Credits, 2.

107. Methods in Drawing and Photographing for Thesis and Publication. — Twelve weeks. Credits, 1–3.

108. The Comparative Anatomy of Green Plants. — In the lectures an intensive study is directed to the comparative anatomy of green plants from the evolutionary standpoint. Particular emphasis is laid upon the woody forms both living and extinct. Of the latter, the department is fortunate in possessing excellent sets of micro-preparations and lantern slides. Two lectures and one laboratory period for 24 weeks. Credits, 6.

150. Systematic Mycology. — See undergraduate Courses 52–54.

151. Systematic Botany of the Higher Plants. — See undergraduate Courses 58 and 59.

152. Plant Histology. — See undergraduate Courses 55 and 56.

153. Cytology and Embryology. — See undergraduate Courses 82 and 83.

154. Plant Pathology. — See undergraduate Courses 75–77.

155. Plant Physiology. — See undergraduate Courses 78–80.

180. Seminar. — A weekly seminar for members of the department staff, graduate students and major senior students is held, at which important botanical papers are discussed. Attendance and participation are required. Credits, 3.

190. Collateral Reading. — Extensive reading of botanical literature in English, German and French, designed to give the student a broad knowledge of the science, is required of all major students. Final examinations are based in part upon this reading course. Credits, 5–10.

200. Thesis. — Each major student is required to select a problem in plant pathology or physiology (in other branches at the discretion of the department) for original investigation, and the thesis must embody a distinct contribution to knowledge. An effort will be made to assign problems having some bearing on scientific and economic agriculture. The thesis work counts for not more than 50 per cent of the total number of major credits required for either degree.

Minor Requirements.

For a minor a student may take such of the work offered by the department as seems best suited to his major course. Courses 150 and 155 are primarily undergraduate work which may be taken for minor credit toward advanced degrees. In most cases no problem will be assigned.

Professors Osmun, Anderson, Clark, Torrey and Davis.

Chemistry.

Major Requirements.

For the Degree of Doctor of Philosophy.

Prerequisite Work. — The candidate must have taken undergraduate Courses 1 to 87, or their equivalent.

Required Work. — The candidate will be required to take all the graduate

courses listed below. He may also be required to spend at least two terms or one semester at some other recognized institution, pursuing graduate study in chemistry. For the final examinations, questions will be selected from the entire field of chemistry, with special emphasis upon the lines of work covered by the research.

For the Degree of Master of Science.

Prerequisite Work. — The same as that required for the degree of doctor of philosophy.

Required Work. — The candidate will be required to take Courses 101 and 108 through 114. In addition he will pursue the requirements of one of the following thesis subjects: —

Organic and Biochemistry. — Course 200 and either 105, 106 or 107, and 3 credits for one term selected from Courses 103 (*b*) or (*f*), and 104.

Analytical and Industrial Agricultural Chemistry. — Courses 200, 103 (3 credits), and 3 credits for one term selected from Courses 102 and 104 through 107.

Physical Chemistry. — Courses 200, 104, and 3 credits for one term selected from Courses 102, 103 and 105 through 107.

Agricultural Chemistry. — Courses 200, 103 (3 credits), and 3 credits for one term selected from Courses 102 and 104 through 107.

The candidate must pass a final written and oral examination before the department upon undergraduate Courses 1 through 80, as well as upon all graduate work taken in chemistry.

Graduate Courses Offered.

101. Inorganic Preparations. — Laboratory. The preparation of chemical products from raw materials. The manufacture and testing of pure chemicals. The laboratory work is essentially synthetic in nature, and is designed to aid in acquiring a more adequate knowledge of inorganic chemistry than is to be obtained by chemical analysis alone. Ten to fifteen of the preparations given in Biltz's "Laboratory Methods of Inorganic Preparations" will be made by each student. Any term. Credits, 3.

Assistant Professor Serex.

102. Advanced Inorganic Preparations. — Laboratory. Continuation of Course 101. Any term. Credits, 3.

Assistant Professor Serex.

103. Advanced Analytical Chemistry. — Laboratory. This course may be taken in part as follows: (*a*) electrolytic analysis, 3 credits; (*b*) ultimate analysis, 3 credits; (*c*) special analytical work to meet the needs of the individual student, 3 credits. In addition, parts of undergraduate Courses 62, 76 and 77 may be taken, as follows: (*d*) fertilizers, 3 credits; (*e*) insecticides, 3 credits; (*f*) milk and butter, 3 credits. (*a*), (*b*), (*c*) may be taken any time; (*d*), (*e*), (*f*) must be taken at the time the undergraduate course is given.

Professors Wellington and Peters.

104. Advanced Physical Chemistry. — Laboratory. Measurement of the electrical conductivity of solutions; degree of ionization; ionization constants; per cent hydrolysis of aniline hydrochloride from conductivity measurements; solubility product by the conductivity method; velocity of

saponification by conductivity; neutralization point by conductivity; vapor pressure determinations; critical temperature of carbon dioxide or sulphur dioxide; transport numbers; preparation and properties of colloidal solutions; transition points by dilatometric method; heat of solution of ammonium chloride and potassium nitrate; adsorption of iodine by charcoal; splitting of racemic glyceric or racemic tartaric acid into its optical components. To each student separate work will be assigned. Any term. Credits, 3.
Assistant Professor SEREX.

105. ADVANCED ORGANIC PREPARATIONS. — Laboratory. The preparation of compounds not included in Courses 51 and 52, such as the Kolbe synthesis of salicylic acid; benzophenone and Beckmann's rearrangement; rosaniline, malachite green, Congo red, indigo and other dyes; synthesis of fructose; Grignard reaction. Barnett, Cain & Thorpe, Gattermann, Noyes, Fischer and other laboratory guides are used. To each student separate work will be assigned. Any term. Credits, 3.
Professor CHAMBERLAIN.

106. ADVANCED BIOCHEMISTRY. — Laboratory. The hydrolysis of proteins and isolation of the amino acids; the study of milk, blood and urine; dietary and digestion studies. References: Abderhalden, Plimmer, Salkowski, Hawk, etc. To each student separate work will be assigned. Any term. Credits, 3.
Professor CHAMBERLAIN.

107. INDUSTRIAL ORGANIC CHEMISTRY. — Laboratory. The preparation, on a large scale, of wood alcohol, acetic acid, ethyl alcohol, benzene and cellulose products, such as mercerized cotton and artificial silk. References: Molinari, Rodgers & Aubert, Thorpe, Enzyklopädie der tech. Chemie, etc. To each student separate work will be assigned. Any term. Credits, 3.
Professor CHAMBERLAIN.

108. THEORETICAL CHEMISTRY. — Lectures. The following topics are considered: the compressibility of the atoms; the structure of atoms; the electron conception of valence. First term. Alternates with Course 109.
Credit, 1.
Professor PETERS.

109. ANALYTICAL CHEMISTRY. — Lectures. A general survey of methods and technique covering processes commonly carried out in the laboratory. Gooch's "Quantitative Analysis" is used as a text. First term. Alternates with Course 108. Credit, 1.
Professor PETERS.

110. ORGANIC CHEMISTRY. Lectures. Some of the following topics will be considered both theoretically and industrially: alkaloids, synthetic dyes, essential oils, terpenes, rubber, etc.; the study of methods for carrying out general reactions; isomerism, tautomerism, condensation, etc. References: Cain & Thorpe, Cohen, chemical monographs, Lassar-Cohn, Heinrichs, Molinari. Second term. Alternates with Course 111. Credit, 1.
Professor CHAMBERLAIN.

111. BIOCHEMISTRY. — Lectures. Some of the following topics will be considered both chemically and physiologically: fats, cholesterol, lecithin, carbohydrates, amino acids, proteins, urea, uric acid, purine bases, enzymes,

fermentation, animal food and nutrition, photosynthesis. References: Monographs on biochemistry, Abderhalden, Plimmer, Haas & Hill, Lewkowitsch, Fischer, Euler, Mathews, Czapek. Second term. Alternates with Course 110.
Credit, 1.
Professor CHAMBERLAIN.

112. THEORETICAL AND PHYSICAL CHEMISTRY. — Lectures. The relation between the constitution and properties of compounds; mutarotation; steric hindrances; stereoisomerism of other elements than carbon; molecular association; similarity between the compounds of silicon and carbon. Third term. Alternates with Course 113. Credit, 1.
Assistant Professor SEREX.

113. THEORETICAL AND PHYSICAL CHEMISTRY. — Lectures. Radioactivity; the application of physical chemistry to industrial chemistry. Third term. Alternates with Course 112. Credit, 1.
Assistant Professor SEREX.

114. SEMINAR. — Conferences, reports or lectures. Three terms, twice a month. Credit, ½.
Professor LINDSEY.

200. THESIS. — Research, and, in the case of a degree, the preparation of an acceptable thesis in agricultural, analytical, organic or physical chemistry, under the direction of the professor in charge of the work, provided that a candidate for the degree of doctor of philosophy shall have had the equivalent of Courses 51, 52, 65 and 86. Credit determined by work done.

MINOR REQUIREMENTS.

Work may be selected from any of the undergraduate Courses 27 and 51 to 80, or any of the graduate courses for which the student is prepared. In addition, the candidate may be required to pass a final written and oral examination before the department upon his entire minor work.

Entomology.

MAJOR REQUIREMENTS.

For the Degree of Doctor of Philosophy.

PREREQUISITE WORK. — Students must have had all the undergraduate courses given at this college or their equivalent. Opportunities to make up any deficiencies will be available while the graduate work is being carried on.

REQUIRED WORK. — The graduate courses consist of lectures on all, and laboratory work on a part, of the subjects given below, together with advanced readings, seminar work and original research.

For the Degree of Master of Science.

PREREQUISITE WORK. — The same as for the degree of doctor of philosophy.

REQUIRED WORK. — A major course for the master of science degree will be about half of the courses listed below.

Graduate Courses Offered.

100. Morphology. — 1. Embryonic development of insects and polyembryony.

2. Metamorphosis and its interpretations.
3. Advanced external and internal anatomy.
4. Insect histology.
5. Ancestry and development of insects, including fossil insects.
6. Hermaphrodites in insects.
7. Hybrids.
8. Parthenogenesis, pedogenesis and heterogeny.
9. Chemistry and physics of insect colors.
10. Color patterns, their significance and value.
11. Luminosity.
12. Deformities.
13. Variation in insects.

120. Ecology. — 1. Dimorphism and polymorphism.

2. Mimicry, including concealment, protective devices and warning coloration.
3. Architecture of insect structures.
4. Relation of insects to plant fertilization and its importance.
5. Insect products of value to man.
6. Geographical distribution and methods of distribution of insects, with a consideration of life zones, barriers, etc.
7. Insect migrations.
8. Insect behavior and experimental entomology.
9. Enemies of insects.

140. Economic Entomology. — 1. Control methods.

2. Insect photography and methods of preparing illustrations.
3. Field work and life history investigations with methods for keeping records.
4. Legislation about insects.
5. Studies of insecticides and their application.

160. Systematic Entomology. — 1. History of entomology and of classifications.

2. Lives and works of prominent entomologists.
3. Abundance of insects.
4. Important collections, public and private; their location and their value.
5. Types of insects; their significance, importance and location.
6. Rules of nomenclature and how they are used.
7. Methods for collecting, preparing, preserving and shipping insects.

180. Seminar. — Readings and reports on the current literature of entomology; monthly meetings.

190. Collateral Readings. — The best articles on the various topics in entomology are assigned for collateral readings, and are included in the final examinations.

200. Thesis. — Original research on one or several topics in morphology, ecology, economic and systematic entomology. This is expected to require from one-half to three-quarters of the total working time of the student.

Minor Requirements.

Minor courses will cover such parts of the work outlined above as will be most likely to prove useful in connection with the majors taken by the students, or in their future work. It is not required that such men shall have had all the undergraduate work in entomology given at this college, their credit for a minor beginning where their own undergraduate training in the subject ended.

Horticulture.

Graduate work is offered in various lines of horticulture. For the most part this is divided into the different departments which constitute the college Division of Horticulture, as follows: pomology, floriculture, landscape gardening, forestry and market gardening. For work in these lines application should be made direct to the heads of the several departments.

Besides this work, however, opportunity is offered for graduate study in general horticulture, including topics from the several organized departments mentioned, and also questions relating to plant breeding, general evolution, propagation, manufacture of horticultural products, etc. This general work is under the direction of Professor Waugh, head of the Division of Horticulture.

Landscape Architecture.

Major Requirements.

For the Degree of Master of Landscape Architecture.

Prerequisite Work. — The undergraduate courses in the college known as Landscape Gardening 50, 51 and 52, Drawing 25, 26 and 27, Horticulture 27, 50 and 51, and Mathematics 26 and 27 will be considered prerequisite to graduate work, and any student who has not passed these courses, or their equivalent, will be required to make up such work without graduate credit.

Required Work. — Each student before he may receive the master's degree with a major in this department must convince his instructors that he has a genuine aptitude for some branch of landscape gardening, either in design, construction or management.

The minimum period of graduate study will be one and one-half years. At least one year of this time must be spent in residence at the college. One year must also be spent in practice outside the college. The work done outside the college may be prescribed by the department, and must be fully reported to the department in writing. It is essential, further, that the candidate secure the written approval of his employers outside the college. The department may, at its discretion, require a longer period of study at the college or a longer apprenticeship outside the college.

Every student before receiving his master's degree in landscape architecture must have given some thorough and fruitful study to each of the following five departments. As far as possible these studies must be of a practical nature, *i.e.*, they must be made upon actual projects in progress of development.

1. *Theory.* — The principles of esthetics as applied to landscape architecture.

2. *Design.* — The principles of pure design and their application in landscape and garden planning.

3. *Construction.* — The practical methods of carrying out landscape plans, laying out, equipment, organization of working force, time and cost keeping, etc.

4. *Maintenance.* — Methods, organization, cost.

5. *Practice.* — Office work, drafting, estimating, reporting, charges, accounting.

While great freedom is allowed to graduate students in their plans of work, a certain portion of time will always be given to systematic courses of instruction. Courses known as Landscape Gardening 175, 176, 177, 178, 179, 180, 181 and 182 are required, and may or may not be accepted for graduate credit, at the discretion of the department.

Graduate Courses Offered.

175. Theory of Landscape Art. — Same as Landscape Gardening 75. First term. Credits, 3.
Professor Waugh.

176. Civic Art. — Same as Landscape Gardening 76. Second term. Credits, 4.
Professor Waugh.

177. Country Planning. — Same as Landscape Gardening 77. Third term. Credits, 4.
Professor Waugh.

178. Architecture. — Same as Landscape Gardening 78. Third term. Given in alternate years. Credits, 3.
Assistant Professor Harrison.

179. Construction. — Same as Landscape Gardening 79. Third term. Given in alternate years. Credits, 3.
Assistant Professor Harrison.

180. Theory of Design. — Same as Landscape Gardening 80. First term. Credits, 4.
Professor Waugh.

181. Estate Design. — Same as Landscape Gardening 81. Second term. Credits, 4.
Assistant Professor Harrison.

182. Park Design. — Same as Landscape Gardening 82. Third term. Credits, 4.
Assistant Professor Harrison.

190. Theory. — Special studies. Credits, 2–10.
The Department.

191. Design. — Individual problems by arrangement. Credits, 2–10.
The Department.

192. Construction. — Individual problems by arrangement.
Credits, 2–10.
The Department.

193. Maintenance. — Special studies, experimental work or assigned problems.
Credits, 2–10.
The Department.

194. Practice. — Professional field work under supervision. By arrangement.
Credits, 2–10.
The Department.

195. Seminar.
Credits, 1–5.
Professor Waugh.

200. Thesis. — Each student before receiving the master's degree with a major in landscape architecture must present a satisfactory thesis or complete project. A thesis will consist of a careful original study of some problem in landscape architecture, presented in typewritten form with any necessary illustrations, such as photographs, diagrams, drawings, etc. A project will consist of a completed set of studies of some suitable landscape-gardening problem, such as the design of a park, a real estate subdivision, an extensive playground. Such a project will usually consist of —

(*a*) Original surveys, including topography.
(*b*) Block plans, showing original design.
(*c*) A rendered plan or plans of the main features.
(*d*) Detailed working drawings.
(*e*) Estimates of cost.
(*f*) Complete report and letter of transmittal.

Credits, 5–20.

Minor Requirements.

Any student electing a minor in landscape architecture will be directed to take such courses from the regular catalogue list as may seem most suitable to him. Under ordinary circumstances no other work will be given to students electing minors. In special cases, however, individual problems will be assigned and individual instruction given. These exceptions will be made in cases where, by so doing, it is possible to give the student material assistance in the plan of his major work.

Microbiology.

Major Requirements.

For the Degree of Doctor of Philosophy.

Prerequisite Work. — Candidate must have had Courses 50, 51, 52, 80, 81, 82 and 83, or their equivalents, before he can enter upon graduate work.

Required Work. — Studies will be selected from the courses offered below. It will be the purpose of the department to distribute such studies among the courses offered in a manner to gain the greatest efficiency and a comprehensive knowledge of the entire field. The work will be conducted by prescribed readings, critical written reviews, conferences, lectures and laboratory exercises.

For the Degree of Master of Science.

Prerequisite Work. — The same as for the degree of doctor of philosophy.

Required Work. — Courses of a basic and applied character selected from the courses offered below which will prepare the student for effective effort.

Graduate Courses Offered.

100. History of Microbiology. Credits, 5–10.

110. Cytological and Morphological Studies and Corresponding Technique. Credits, 5–10.

120. Studies in Technique and Methods. Credits, 5–20.

130. Physiological Studies. Credits, 5–20.

135. Industrial Fermentations. Credits, 5–10.

140. Agricultural Microbiology — General Survey. Credits, 5–20.

141. Microbial Studies in Agriculture. Credits, 5–10.

150. Soil Microbiology. Credits, 5–20.

160. Dairy Microbiology. Credits, 5–20.

170. Food Microbiology. Credits, 5–20.

180. Hygienic Microbiology. Credits, 5–20.

181. Special Sanitary or Hygienic Studies. Credits, 5–10.

190. Lectures and Study of Literature. Credit, 1 each term.

200. Thesis. — Some microbiological problem related to agriculture or food. Distributed as may be most beneficial for research work. Time and credit by arran ement. Credits, 15–50.

Minor Requirements.

Minor work in microbiology may consist of undergraduate Courses 50, 51, 52, and other courses designed to support the major work, from among the courses offered above. The candidate will also be required to pursue graduate Course 190, or follow a course of reading and conferences through three terms. In case the candidate has had some of these courses, he will be required to take more advanced substitute courses.

Poultry Science.

Major Requirements.

For the Degree of Master of Science or Master of Agriculture.

Prerequisite Work. — The postgraduate course presupposes all undergraduate work or its equivalent, together with practical experience. Without the latter, students will be unable to handle Courses 140, 150 and 160. At the

discretion of the instructor in charge, graduate students may be required to pursue undergraduate courses in other departments without credit.

Required Work. — All the courses listed below. Practical poultry work may be required, but no credit will be given for such work.

Graduate Courses Offered.

101. Reading. — A review of the entire field of poultry literature, covering books, bulletins and special articles, is made, and a written report on one or more subjects required.

110. Seminar. — A critical review and a criticism of the more important experiments carried on at various stations in this and other countries; also a study of poultry conditions in foreign countries, methods of management, etc., besides a detailed study of some of the largest poultry projects in this country.

120. Anatomy (Gross and Histological), Physiology and Surgery. — This course requires a careful study of the anatomy and physiology of the fowl. Special attention is given to a study of those structures concerned with practical poultry problems. Instruction in surgical technique, adapted to fowls, may also be given.

130. Breeding. — The student will carry on such breeding experiments as time and facilities permit. He may also do work in connection with our regular experimental projects. A detailed study of the pertinent literature will be required. Animal Husbandry 5, or its equivalent, is a prerequisite.

140. Feeding. — A study of the relation of various foods and other substances to the morphology and physiology of the bird, with special reference to such subjects as egg production, feather form and structure, condition of flesh, bone, etc.

150. Brooding. — Studies will be made upon the relation between viability and rate of growth and the following topics: type of brooder, number of chicks in brood, ventilation, humidity, sanitation, exercise and weather conditions; also a comparison of natural methods with artificial methods of rearing chicks.

160. Incubation and Embryology. — A number of problems of a practical, scientific and mechanical nature relating to incubation are considered. The work in embryology is of an advanced nature, dealing with its relation to morphogenesis and heredity, and presupposes an elementary knowledge of the embryology of the chick.

170. Poultry Diseases and Sanitation. — In this course a study is made of various problems in poultry sanitation, with particular reference to methods relating to the control and eradication of disease.

200. Thesis.

Minor Requirements.

Courses 101 and 110 are designed particularly for minors.

Rural Sociology.

Major Requirements.

For the Degree of Doctor of Philosophy.

Prerequisite Work. — Candidates must present satisfactory evidence of having completed at least 10 credit hours in general sociology and 10 credit hours in general economics; or take such undergraduate courses as the department may designate to satisfy this requirement.

Required Work. — Candidates must take or pass by satisfactory examination courses offered by the department for undergraduates bearing the numbers 26, 50, 51, 52 and 75, and such courses in agricultural education and agricultural economics as may be required, not to exceed 10 credit hours in each department. Candidates will be required to select from the courses listed below as graduate courses a field for investigation and intensive study. Candidates for the doctorate must take all courses listed as graduate.

For the Degree of Master of Science.

Prerequisite Work. — The same as for the degree of doctor of philosophy.

Required Work. — Not less than 50 credit hours will be required from the courses listed below. The department will make such selection as may best meet the interest of the individual student.

Graduate Courses Offered.

177. Field Work of an Investigational Nature.

178. Rural Social Surveys.

179–181. Seminar.

182. Social Conditions of American Rural Life.

183. Social Conditions of European Rural Life.

184. Rural Institutions.

185. Rural Organization.

186. Farmers' Organizations.

187. Town and Village Rural Life.

188. Rural Health and Sanitation.

189. Rural Literature.

190. Rural Government and Law.

200. Thesis.

Veterinary Science.

Work is available in hygiene, veterinary pathology, and other special lines or divisions of the subject.

Zoölogy.

MINOR REQUIREMENTS.

Courses in zoölogy may be available as a minor for the degrees of doctor of philosophy and master of science. The nature of the work will necessarily vary according to circumstances, and may be intensive in a special field and correlated closely with the major work of the student, or it may be of a more general character, depending on the student's needs or previous acquaintance with general zoölogical science.

LIST OF STUDENTS.

A list of the degrees conferred in the Graduate School, and of the students enrolled, is given in the general lists at the end of the volume.

The Short Courses

THE SHORT COURSES.

The short courses offered by the Massachusetts Agricultural College are designed to meet the needs of those, both young and old, who cannot come to the college for the regular college courses. They furnish the student with instruction in modern accepted methods, and are planned to help the farmer and the housewife.

The short courses include: —

A. The Two-year Course in Practical Agriculture.
B. The Ten Weeks' Winter School.
C. The Summer School.
D. The Vocational Poultry Course.

REQUIREMENTS FOR ADMISSION TO SHORT COURSES. — Students must be at least seventeen years of age, and must furnish satisfactory evidence of good moral character. References are required. There are no entrance examinations. The sole test is ability to do the prescribed work. Students enrolling for the Two-year Course in Practical Agriculture must have at least a common school education.

EXPENSES OF SHORT COURSES. — The expense of attending any of the short courses is approximately as follows: —

Furnished rooms in private houses (per week)	$3 to $5
Board at college dining hall (per week)	$7
Board with private families (per week)	$6.50 to $9
Registration fee (Ten Weeks' Winter School)	$5

Tuition in all the short courses is free to residents of the Commonwealth. Small laboratory fees are charged in some of the courses.

A. TWO-YEAR COURSE IN PRACTICAL AGRICULTURE.

The Two-year Course in Practical Agriculture is offered to meet the needs of students who for one reason or another cannot take the four-year college course. It is designed to provide a large amount of practical information and training in agriculture and horticulture.

It will appeal, not only to young men and women, but also to men and women of mature years and practical experience who wish to know more about the business of farming. Although the course is planned to meet the needs of those who are not graduates of high schools, the instruction is not preparatory or elementary in its nature, but is so planned that it will be of value to all. The greater amount of academic training that some of the students may possess will in a measure be offset by the fund of practical knowledge possessed by many who have completed only the elementary schools.

The course is not intended for students enrolled in high schools. Such students should finish the high school course. Students enrolled in high schools who wish to take the course should bring a statement either from the principal of the high school or from parent or guardian asking permission to be enrolled.

The Two-year Course in Practical Agriculture is arranged so as to provide specific vocational training for the particular lines of agricultural work which the students may select. When a student enrolls he is required to state the type of farming in which he expects to engage; and to select from the following courses of study the one he wishes to pursue: —

1. General agriculture, with animal husbandry as the principal subject.
2. General agriculture, with poultry as the principal subject.
3. Dairy manufactures.
4. General horticulture.
5. Pomology.
6. Floriculture.
7. Vegetable gardening.

He then pursues a specially arranged course of preparation for that type of work. This specialization does not prevent his securing a general working knowledge of other subjects in which he may be interested.

The advantages of the college staff of specialists and the college plant with all its resources are thus made available to young men and young women who may not have had the opportunity of securing a high school education.

The first year consists of six months of study at the college. The term begins with the college fall term and closes with the winter term of the regular session. The same vacation periods are observed as in the regular four-year course.

At the close of six months of study, students are required to gain six months of farm experience. The college will assist students in finding positions and in placing them on farms where the experience gained will be of great advantage. Thus an effort will be made to place on a dairy farm the man expecting to take up dairying as his chief line of work, and a student of pomology on a fruit farm.

During the second year the student spends nine months in resident study, completing the subject pursued in the first year.

Each student is required to file with the treasurer of the college a statement, signed by the town (or city) clerk of the town (or city) from which he enrolls, stating that the parent or guardian of the student is a resident of that town.

Certificate. — All students will receive a certificate showing their standings in courses in which they were registered. Credits earned in the Two-year Course in Practical Agriculture or in any other of the short courses do not lead to the college degree. Students who possess college entrance requirements and who wish to take the regular college work should address the registrar of the college.

B. THE WINTER SCHOOL.

The Winter School, beginning usually about January 1 and continuing for ten weeks, was started several years ago, and has always been very popular, not only with more mature farmers and their wives, but with young men and women who control or manage farms. The courses, though short, are

very practical in their nature, and are so arranged that a student may choose such subjects as will enable him to specialize along the line of work in which he is most interested. There is a wide range in the choice of subjects, making it possible for the student to take work for several winters in succession. Many college graduates enroll for the Winter School.

Scholarships. — The Jewish Agricultural and Industrial Aid Society of New York has instituted a system of free scholarships to enable the children of Jewish farmers to attend the short winter course in the States in which they reside. The stipend is sufficient to pay all the expenses of the holder for the course. Such expenses usually amount to from $100 to $150. The following courses are offered: —

Outline of the Ten Weeks' Winter School, January 2 to March 10.

Soil Fertility. Three lectures a week.
Field Crops. Two lectures and one two-hour laboratory period per week.
Types and Breeds of Livestock. Three lectures and two two-hour laboratory periods a week.
Livestock Feeding. Three lectures per week.
Animal Breeding. One lecture and one two-hour laboratory period per week.
Dairying. Five lectures and five laboratory periods per week.
Dairy Bacteriology. Two lectures and one two-hour laboratory period per week.
Animal Diseases and Stable Sanitation. Two lectures per week.
Poultry Husbandry. Five lectures and one two-hour laboratory period per week.
Fruit Growing. Three lectures and one two-hour laboratory period per week.
Market Gardening. Three lectures and two two-hour laboratory periods per week.
Floriculture. Five lectures per week.
Horticultural Manufactures. Two lectures and two laboratory periods per week.
Farm Management. Two lectures a week.
Farm Accounts. Two two-hour laboratory periods per week.
Marketing. Two lectures a week.
Agricultural Credit. Two lectures a week.
Botany. Two lectures a week.
Entomology. Three lectures per week.
Farm Structures. Two lectures and one two-hour laboratory period per week.
Farm Machinery. Two lectures and three two-hour laboratory periods a week.
Rural Sanitary Science and Hygiene. Two lectures per week.
Vocational Guidance. One lecture per week.
Foods. One lecture and two two-hour laboratory periods per week.
The Business of the Household. Three class hours per week.
Home Care of the Sick. Three class hours per week.
Principles and Methods of Vocational Agricultural Teaching. Five exercises per week.
Special Methods in Vocational Agricultural Teaching. Five exercises per week.
Professional Improvement Problems. Five periods per week.

C. THE SUMMER SCHOOL.

The summer school has been maintained by the college for a number of years. The experience of these years has been a value in arranging short, intensive, practical courses that will meet the needs of teachers, home makers and professional workers, who wish instruction in agriculture, agricultural education and home economics, and who can most conveniently come to the college during the summer. The instruction is given by the regular members of the college staff, assisted by outside lecturers. In previous years the term has been four weeks.

The nature of the work of the summer school is indicated by the following typical program: —

Agriculture and Horticulture: —
- Poultry husbandry.
- Fruit growing.
- Flower growing.
- Vegetable gardening.
- Food preservation.
- Beekeeping.

Home economics: —
- Foods and nutrition.
- Preparation and serving of meals.
- Garment making.
- Dress design and construction.
- Millinery.
- House furnishing.
- Home management.

Related subjects: —
- Insect life.
- Bird life.
- Recreation.
- Dramatic presentation.
- Design and practical arts.
- Rural sociology.
- Hygiene and sanitation.

Agricultural education: —
- Principles and methods of teaching.
- Special methods in vocational agricultural teaching.
- Professional improvement problems.
- Supervision and administration of agricultural education.
- Vocational education.

D. ONE–YEAR VOCATIONAL COURSE IN POULTRY HUSBANDRY.

Purpose. — This course is designed for graduates of the agricultural vocational schools and others who wish to prepare themselves for practical poultry keeping, and can spend only one year at college.

Scope. — The work covers seven detailed courses in poultry husbandry, as well as short-course work in fruit growing, market gardening, animal husbandry, or other subjects that will be helpful to poultry raisers. In addition to classroom and laboratory exercises each student is required to put in from twenty-five to thirty hours per week at the plant in the care and management of poultry, for the purpose of becoming proficient in the various branches of the work.

Entrance Requirements. — Applicants must be at least eighteen years of age and have a good elementary education.

Fees. — There is no tuition for residents of Massachusetts, but a laboratory fee of $5 is required for both the fall and spring terms.

Note. — The course is limited to sixteen students. The One-year Poultry Course begins in December and continues until the following December.

Due to a strong demand for the course, it was necessary to start a second class in vocational poultry at the beginning of the winter term. Thirty students were enrolled in both classes of vocational poultry.

THE EXTENSION SERVICE

The Extension Service.

The Extension Service is the organized effort of the whole Massachusetts Agricultural College in educational service to the citizens of the Commonwealth who cannot enter as resident students. Its task is to make available all the useful and practical information discovered by the efforts of the Experiment Station, reinforced by the United States Department of Agriculture and the experiment stations of other States. The Smith Lever Act defines extension work as "the giving of instruction and practical demonstrations in agriculture and home economics to persons not attending or resident in colleges — and imparting to such persons information on said subjects through field demonstrations, publications and otherwise."

The Extension Service is a recognized part of the college organization, with a staff giving full time to extension work; yet the actual working force is much larger because many of the resident faculty and research staff give time to extension work, the specialists of the United States Department of Agriculture are frequently in the State on special problems, and the staffs of the County Extension Services, who co-operate as local representatives in the extension organization, are in direct and constant touch with the problems and the people of the State.

It is impossible to discuss the Extension Service without including these co-operating agencies, — the United States Department of Agriculture and County Extension Services. While the extension staff at the college receives its major support from the State Legislature, Federal funds are received through the Department of Agriculture, and are used, according to act of Congress, in the support of work both at the college and in the counties. In addition to these funds the County Extension Services, which are supervised by the Trustees for County Aid to Agriculture, receive from county and town appropriations still larger amounts, all of which must be applied to extension work.

Personnel.

College Extension Staff. — Extension work at the college is organized with a director in charge, and under him three State leaders who are joint employees of the State and Federal government. The State leaders are in charge of county agent work, home demonstration work and junior extension work, respectively. Extension specialists are employed in the following subject-matter fields: agronomy, animal husbandry, poultry husbandry, pomology, horticultural manufactures, marketing, farm management, clothing efficiency and nutrition. In addition, the Extension Service employs an assistant director who is a specialist in methods of extension instruction and in office and field organization; a supervising specialist in charge of extension schools, agricultural exhibits and extension courses at the college; and an extension editor who is also supervisor of correspondence courses. The State leader of

junior extension work also has three assistants, each in charge of specialized subject-matter branches.

COUNTY EXTENSION STAFFS. — In each county in the State, with the exception of Suffolk, Dukes and Nantucket, a staff of extension agents is maintained. In eight of the counties these agents are employed by a Board of Trustees for County Aid to Agriculture, and in three counties by the Trustees for the County Agricultural School of the County. In each of these eleven counties are a county agricultural agent, a county home demonstration agent and a county club agent. These are joint employees of the county, the college and the United States Department of Agriculture. Their major responsibility is to their county trustees, yet on the basis of co-operative projects they are a very important part of the total extension staff of the State. In addition to these three agents co-operatively employed in each county, there are in many of the counties assistant agents.

Because of the co-operative relation with the Federal government, it is possible to secure much assistance from the Department of Agriculture in Washington. Subject-matter specialists are employed by the States Relation Service in the major branches of agriculture and home-making. In addition, the research facilities of the Department of Agriculture, the Division of Publications, the Bureau of Markets, and many other sub-offices within the Department are constantly furnishing help in solving problems in the State, and frequently Federal staff members assist the staff members of either college or county with particular problems.

CO-OPERATION OF AGENTS. — In the extension program as now being carried out the Department of Agriculture furnishes a certain amount of finance and a great deal of supporting information resulting from the research work of the experiment stations, this being by conference with the extension specialists of the State and county, and not as a direct service to the people of the Commonwealth. It is the function of the extension specialist at the college to be what the name implies, — to be constantly up to the minute in the subject-matter of his specialty, organizing information and preparing it in proper form for the use of the county agricultural agents; to head up the development program in his subject-matter in the entire State, and thus furnish a correlation between the Department of Agriculture and its research work, the forces of the teaching and experimental faculty at the college, and the county agents who are in immediate contact with the people of the State. It is obvious that no county agent can be a specialist in all branches, and that all the county agents will need the specialist's support in many branches. The specialist has now become much less a direct teacher of farmers and home-makers, and much more a consultant and adviser with the county agents on the problems which are too deep or too intricate for solution by them. The county agents in agriculture, home economics and junior club work are at present making the real contacts with the people of the State; they study the problems at first hand, and organize the demonstrational programs. It should be noted that they are part of a national staff, over 2,000 counties in the United States employing county agricultural agents, all of whom are related in a single movement to the United States Department of Agriculture, 800 home demonstration agents and 300 junior club agents. Thus it will be seen that the extension staff from the Department of Agriculture in Washington, and including the remotest experiment station on the Pacific coast, is organized to avoid duplication of function. The tasks of each group are quite distinct.

Projects and Programs. — Because it is impossible for a staff of limited number to meet personally all the farmers and home-makers of the State relative to problems, it has been necessary to devise a system of education which would make available in the most positive form to the greatest number of people such information as it seems desirable to impart. The demonstrational methods are the ones finally accepted as most effective. Demonstrations of the best practices in agriculture and home-making are maintained by the co-operation of farmers and home-makers throughout the Commonwealth, from the tip of Cape Cod to the westernmost Berkshires. The co-operators undertake to do certain operations or conduct certain enterprises according to the approved method and in co-operation with the agents. The results of their efforts are used as a basis of teaching. Where the method is one with visible results, as in the comparison of seed potatoes or in spray control of orchard pests, the attention of farmers and home-makers in the vicinity of the demonstration is directed to it, and frequent conferences and meetings are held in order that the approved method may be understood. The time of the county agent is therefore primarily spent with the co-operating farmers and home-makers, who are known as demonstrators. A great amount of personal service is also undertaken in the form of conferences, consultations, advice and correspondence, etc. This, however, must give place to the systematic demonstrational work which endeavors to stress the most important subjects in the various branches of agriculture and home-making. In this demonstrational program the specialists work out the basis of the demonstrations, provide the informational material, and supervise the method of carrying out in regard to data and analysis of results, and the county agents arrange with the demonstrators and give personal attention to the demonstrations themselves.

Projects and Plans of Work.

In order that this work may be definite it is organized on a project basis. The agronomy project, for instance, defines the needed practices or changes in practices with regard to soil fertility and crops. The most fundamental things are selected as a basis of intensive work, and each year a program of work is written jointly by the specialists and county agents defining the particular steps in the long-term program which are to be carried forward during the year. The communities of the State decide which of the various projects, and which phases of these projects, are most important in their communities, and arrange co-operation with the county agents and specialists.

It will be noted from the foregoing that the work is organized in three major lines, — agriculture, home-making and junior extension. The first two are divisions in subject-matter; the third utilizes the same subject-matter as the projects in agriculture and home economics, but adapts it to the needs of young people. It is built on the principle that boys and girls and young men and women can receive and give great benefits if they will elect productive tasks and follow them systematically. The junior clubs, so called, are built on the basis that there are many productive and interesting and worth-while tasks in agriculture and home economics. It is the task of the junior extension agent to adapt adult material to the needs of this younger clientele.

Types of Work.

Demonstrations. — Demonstration work is of primary importance in the extension program. Demonstrations may be of various types: demonstrations of practice, as illustrated by a system of crop rotations; a demonstration of operation, as in grafting, spraying, poultry killing and culling, etc.; and comparative demonstrations, as between native and northern-grown seed potatoes, top-dressed and neglected hay land.

Extension Schools. — Through the winter months the Extension Service arranges schools of one to five days' duration, which are held in various communities. At all of these schools intensive attention is given to certain selected subject-matter. The tendency of the past two seasons has been toward the one or two subject school rather than the general extension school of the past. The teaching is usually divided between the county staff, specialists from the college and co-operating demonstrators who have got notable results in agriculture and home-making.

Fair Exhibits. — The college has undertaken many types of enterprise in the field of fair exhibits. At present, lack of funds will prevent any great effort in the way of transporting material exhibits. Much is being done by the County Extension Services, supported by the assistance of the college specialists, in the way of demonstrational exhibits at fairs. This type of exhibit seems to promise large development. It is hoped, also, that physical arrangement may be made whereby the college live stock can be exhibited more freely. At present this is impossible, owing to the fact that funds are not available, and premiums earned or won by the live stock must revert to the State treasury, and are therefore unavailable for defraying the expenses of such exhibits.

Conferences at the College. — All conferences at Amherst of two weeks duration or less are considered extension activities. The largest of these is the summer Farmers' Week coming during the last week in July, and buil upon the principles of demonstration meetings at various advantageous places on the farm, utilizing the physical equipment of the orchards, the fields and the barns as a conferential basis. In addition to this, meetings of many organizations are held at the college, as in the case of the sheep breeders, the fruit growers, the onion growers, the poultry growers, etc. Many of these are held in connection with the summer Farmers' Week, but it is advantageou to hold others during the winter time according to the needs of a particula group. It is also the policy of the Extension Service to bring to the college not only the county staff for annual and other conferences, but to bring i the men and women of the State who are co-operating and leading, in orde that they may have special training in the subject-matter of their efforts.

Correspondence Courses. — The Extension Service maintains a corre spondence course division, and offers correspondence courses at a fee of $5 i the following subjects: soils and fertilizers, field crops, feeding farm animals fruit growing, — which is divided into three parts, comprising apple growing peach and plum culture, and small fruits, — vegetable gardening, floricu ture, farm management, forestry, poultry husbandry, market milk and be keeping.

Publications. — The work of the Extension Service is supported by exten sion publications which are prepared with the intent to meet the needs of th people of the State for concise practical information. It is not the functio

of the Extension Service to provide voluminous textbooks free, but rather, manuals of practice and of information which will give in the most concise and usable form the instructions necessary to the practices of agriculture and home-making. The entire literature of the Extension Service is being revised to this basis, the Extension Leaflets being small units reduced to the simplest terms and the smallest compass, telling a complete story. The series of leaflets in a subject-matter division make a larger bulletin, and the collection of all the leaflets will ultimately make a manual of practice for the average farmer or home-maker of the State. About 1,200,000 pages were printed last year. All the publications of the Extension Service are free. In addition to this it is the practice of the Extension Service to keep a large stock of publications of other colleges, experiment stations, and of the United States Department of Agriculture. These also are distributed free. Stocks of these publications are kept in the offices of the county agents, and can be obtained by application to them. Outside of these publications the Extension Service publishes monthly two small periodicals. "The Monthly Report of Extension Work for Market Gardeners" is a small pamphlet similar to the Extension Leaflets, and the "Extension Service News" is in the form of a small newspaper. These also may be had for the asking.

Lectures. — During the course of the year a great deal of lecture work is done by the county agents and the specialists of the college. This service seems to be of diminishing value except in cases where it leads to permanent demonstration work. It is the aim of the college to meet all calls for lectures just as far as the time of the staff will allow, first of all giving preference to the demonstration type of work. Very few calls for lectures have been left unmet during the past year.

Personal Advice. — The staffs in the counties and in the college do much in the way of answering individual queries, either personal or written. This work establishes many valuable contacts, and the college undertakes to perform just as much of it as is possible. However, much of this inquiry is diverted to the offices of the county extension services, the college handling only such phases of the work as cannot be handled in the counties.

Library Extension Work. — The college library has collections of books on specified subject-matter fields, and furnishes these free of charge to the libraries of the State as loan collections. An increasing amount of this work is being done.

Diagnosis and Prescription. — Calls are constantly coming to the college for information which is really diagnosis. Bushels of malodorous hens, bugs of all description, diseased leaves, and fruit are constantly being received. Just as far as the college is able, the trouble is identified and remedial measures suggested. Here, again, the burden is greater than the college is able to bear at the present time with limited staff, and it is further the conviction that service which can be rendered by a professional veterinarian should be rendered by him. Every effort will be made to take care of such requests for such service as cannot be met by a professional veterinarian, although no guarantees can be given that adequate help will be available for this work.

Assistance to State Institutions. — Managers of State institution farms are constantly asking information of one sort or another from the college, and the specialists are co-operating in many problems of agriculture and landscape gardening.

LIAISON ACTIVITIES. — No small part of the work of the Extension Service, particularly the county staffs, is in bringing other agencies to the assistance of the people of the State. Those desiring systematic study are brought in touch with the vocational schools or practical arts classes in case they are unable to come to the college. Communities desiring assistance in health problems are brought in contact with some of the health agencies in the Commonwealth and voluntary health societies, such as the Red Cross, the county public health associations, etc. It is not the function of the Extension Service in any sense to replace these agencies or to compete with them; rather, to divert to them such calls for help as they are able to meet.

REAL EXTENSION. — The real extension work is done, not only by the staff, but by the best farmers and best home-makers of the State who demonstrate the best practices. The Extension Service cannot be considered without considering these co-operating demonstrators. Those who receive instruction in household management, clothing efficiency, nutrition, agronomy, pomology, poultry husbandry, etc., are the real instructors in their neighborhoods. It is the task of the Extension Service to teach the best farmers and home-makers to perfect their teaching technique, and to depend upon them for the general spread of the practice throughout the State.

Requests for information in any of these fields may be addressed to the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

General Information

General Information.

A. FINANCIAL AND ADMINISTRATIVE.

Student Expenses.

Tuition.[1] — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $180 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk stating that the applicant's father is a legal resident of Massachusetts.

All students entering the college for the first time as undergraduates or two-year students are charged a matriculation fee of $5, which in event of a student leaving the institution shall, if all bills due the college are paid, be remitted, or which shall upon graduation be considered as payment for the diploma.

Dormitories and Board. — The college has dormitory accommodations for about 62 men students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suites of three, — one study room and two bedrooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1 to $4 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present, the price of board there is $7 a week.

Expenses.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts, free; others, $180 per year.

	Low.	High.
Matriculation fee, first year	$5 00	$5 00
Room in college dormitories or in private houses	39 00	110 00
Board, $7 per week	245 00	245 00
Laundry, 50 to 85 cents a week	18 00	30 00
Laboratory fees	5 00	25 00
Books, stationery and miscellaneous items	38 00	60 00
	$350 00	$475 00

Other Expenses. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students

[1] This statement applies to those registering as regular or two-year students.

which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student property either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $400 and $500 per year.

Initial Charges.

At the opening of the college year, before students are registered in their classes, the following charges are payable at the treasurer's office: —

	Freshmen.	Sophomores.	Juniors and Seniors.
Matriculation fee	$5 00	–	–
Board (if at college dining hall) four weeks in advance	28 00	$28 00	$28 00
Assessment for support of Social Union	1 50	1 50	1 50
Laboratory fees	5 00	5 00	2 00–10 00
Room rent (if in college dormitory)	–	–	12 00–20 00
Student tax for support of athletics[1]	5 00	5 00	5 00
Student tax for support of nonathletic activities[1]	3 00	3 00	3 00

[1] While this is not essentially a college charge, the treasurer of the college acts as collector for the student activity, and all students are expected to make the payment as indicated. The subscription price of the "Collegian" is fixed by the managers; the amount of athletic tax by vote of the student body.

Laboratory Fees.

The principles observed in establishing laboratory fees are the requirement that students pay for those materials actually used which cannot be supplied by the individual, and that the laboratory fees include a charge sufficient to guard against wanton waste and breakage. Fees may be established for any course without previous announcement. At present, the fees charged are as follows: —

	Per Term.
Agronomy: —	
Course 1	$1 50
Course 27	2 00
Course 50	2 50
Course 51	2 50
Course 75	2 00
Course 77	2 50
Course 78	2 50
Animal husbandry: —	
Course 25	1 50
Course 26	1 50
Course 75	1 50
Course 78	1 00

	Per Term.
Dairying: —	
Course 50	$3 00
Course 51	3 00
Course 75	3 00
Course 76	3 00
Course 77	3 00
Farm management: —	
Course 75	1 50
Course 76	1 50
Poultry husbandry: —	
Course 51	2 50
Course 53	3 00
Course 55	2 50
Course 76	2 00
Course 77	2 00
Rural engineering: —	
Course 25	1 50
Course 26	1 50
Course 75	1 50
Course 78	1 50
Floriculture: —	
Course 50	2 50
Course 51	2 50
Course 52	2 50
Course 53	2 50
Course 75	2 00
Course 76	2 00
Course 77	2 50
Course 55	2 50
Forestry: —	
Course 56	2 00
Course 57	3 00
Course 58	4 00
Landscape gardening: —	
Course 50	2 50
Course 51	2 50
Course 52	2 50
Course 76	3 00
Course 77	3 00
Course 80	3 00
Course 81	3 00
Course 82	3 00
Vegetable gardening: —	
Course 50	2 00
Course 51	2 00
Course 52	2 00
Course 53	2 00
Course 75	3 00
Course 76	2 00
Pomology: —	
Course 54	$4 00
Course 75	4 00

	Per Term.
Drawing: —	
Course 25	$3 00
Course 26	3 00
Course 27	3 00
Botany: —	
Course 3	1 50
Course 25	1 50
Course 26	1 50
Course 50	2 00
Course 51	2 00
Course 52	2 00
Course 53	2 00
Course 54	2 00
Course 55	3 00
Course 56	3 00
Course 75	3 00
Course 76	3 00
Course 77	3 00
Course 78	3 00
Course 79	3 00
Course 80	3 00
Course 82	3 00
Course 83	3 00
Entomology: —	
Course 50	1 00
Course 51	1 00
Course 53	1 00
Course 54	1 00
Course 55	1 00
Course 75	2 00
Course 76	3 00
Course 77	3 00
Course 78	3 00
Chemistry:[1] —	
Course 1	3 00
Course 2	3 00
Course 4	3 00
Course 5	3 00
Course 6	3 00
Course 25	4 00
Course 26	4 00
Course 27	5 00
Course 51	5 00
Course 52	5 00
Course 62	5 00
Course 65	4 00
Course 76	5 00
Course 77	5 00
Course 80	4 00
Course 86	5 00
Course 91	5 00
Course 92	5 00
Course 93	5 00
Course 94	5 00
Course 95	5 00

[1] An additional deposit of $1 for Courses 1 to 6, inclusive, and $2 for Courses 25 to 95, will be required to cover individual breakage. In case the laboratory breakage does not equal the deposit, the balance will be refunded.

	Per Term.
Mathematics and engineering: —	
Course 27	$1 50
Course 78	1 50
Microbiology: —	
Course 1	3 00
Course 3	2 00
Course 50	5 00
Course 51	5 00
Course 52	5 00
Course 75	5 00
Course 76	5 00
Course 80	5 00
Course 81	5 00
Course 82	5 00
Course 83	5 00
Physics: —	
Course 27	3 00
Course 50	3 00
Course 51	3 00
Course 52	3 00
Veterinary science: —	
Course 78	2 00
Course 79	2 00
Course 80	2 00
Course 85	2 00
Course 86	2 00
Course 87	2 00
Zoölogy: —	
Course 25	3 00
Course 26	3 00
Course 50	3 00
Course 51	3 00
Course 52	3 00
Course 54	2 00
Course 75	3 00
Course 76	3 00
Course 77	3 00
Course 79	2 00
Rural journalism: —	
Course 53	2 00
Course 54	2 00
Course 55	2 00
Course 77	2 00
Course 78	2 00
Course 79	2 00
Course 80	2 00
Course 81	2 00
Course 82	2 00
Music (each course)	3 00
Rural home life: —	
Courses 25, 26, 27	1 50
Courses 50, 51, 52	4 00

Rooms.

Students are expected, as far as possible, to occupy rooms in the college dormitories. Students who do not live in the college dormitories must secure rooms approved by the college. The assignment of rooms, and the general supervision of the housing of students, is in charge of the dean. The inspection of student quarters is in charge of the commandant. At the end of each college year all unoccupied rooms will be thrown open for selection, and will be assigned to students according to classes.

Living Accommodations for Women Students.

Women students attending the college live in a dormitory provided for them, and take their meals at Draper Hall, which is located a short distance from the women's dormitory. The women's dormitory accommodates 98 girls, and is furnished. The present charge for room and board for women students is $120 per term.

Student Aid.

Self Help. — Many students are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 and preferably $250 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should undertake work that interferes with his studies, and students should understand that, owing to the large number of applications for employment, no one man can receive a large amount of work at the college. A number of students find opportunities for earning money without depending upon the college to furnish them with work.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and forty or more students are employed at the dining hall.

Application for student labor should be made directly to Kenyon L. Butterfield, president of the college. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

Special Notice to Needy Students. — In the last few years the demand for paid labor on the part of new students has far exceeded the amount of

employment that the college can offer. The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

Memorial Hall.

Soon after the close of the World War the alumni, students, faculty and friends of the college subscribed $150,000 for the erection of a soldier memorial building to be placed on the college campus. This building was completed in the summer of 1921. It is designed to serve as headquarters for the student activities, and as the center of the social life of the institution.

In the basement are bowling alleys, pool tables, a store, post office and barber shop. On the main floor are eight offices for leaders of various student activities, a large reading room, and a beautiful memorial room in which is found the tablet bearing the names of the sons of the college who gave their lives in the great war. On the second floor is an auditorium seating 350 persons. This room is also used for college dances.

Student Accounts.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each term. This rule is strictly adhered to, and no student will be allowed to complete his registration until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each term at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the term he is more than one week in arrears in his payment for board.

All money due for student labor shall at the discretion of the treasurer of the college be applied on account toward any bills that a student may owe to the institution.

Honor Council.

All tests and examinations are conducted under the honor system, which is administered by an Honor Council chosen by the students. Recommendations for discipline are made to the president of the college by the Honor Council.

Student Relations.

The customary high standard of college men in honor, manliness, self-respect and consideration for the rights of others constitutes the standards of student deportment.

The privileges of the college may be withdrawn from any student at any time, if such action is deemed advisable.

It should be understood that the college, acting through its president or any administrative officer designated by him, distinctly reserves the right, not only to suspend or dismiss students, but also to name conditions under

which students may remain in the institution. For example, if a student is not doing creditable work he may not only be disciplined but he may also be required to meet certain prescribed conditions in respect to his studies, even though under the foregoing rules his status as a student be not affected. The same provision applies equally to the matter of absences ("cuts"). According to the rules a student is allowed a certain percentage of absences from class and other exercises. This permission, which implies a privilege and not a right, may be withdrawn at any time for any cause.

Similarly, also, it applies to participation in student activities. Though this will ordinarily be governed by the rules as already laid down, yet, if in the judgment of the college authorities a student is neglecting his work on account of these activities, the privilege of participating in them may be withdrawn for such time as is considered necessary. Moreover, it may be withdrawn as a punishment for misconduct. Prospective students or their parents may, upon application, obtain a copy of the faculty rules governing student relations to the college.

Infirmary.

The college maintains an infirmary for the care of sick or injured students. The buildings now available for this purpose are quite inadequate for the needs of the institution, and it is hoped that in the near future other buildings of this kind may be erected and the general equipment somewhat amplified. At present two small buildings, built especially for hospital purposes, are used for the infirmary.

The following statement outlines the plan followed in the management of the infirmary with respect to students: —

Management of the Infirmary.

Supervision.

1. The infirmary is under the *general supervision* of Prof. Charles E. Marshall, who is designated as Supervisor of the Infirmary. Miss Grace Charman, the resident nurse, with Miss Marguerite Davis as assistant resident nurse, is in *immediate* charge of the infirmary.

Use of Infirmary.

2. Students are urged to go to the infirmary at any time that they are in need of the services rendered by the resident nurse or by a town physician. Inasmuch as the physical director gives special attention to all student diseases, it is to be expected that the majority of the students will go to the infirmary at his suggestion. This understanding, however, should in no way deter students from going to the infirmary voluntarily at any time.

General Health.

3. Students are urged to consult the physical director or the resident nurse immediately when signs of physical disorder appear. Severe attacks of cold or other forms of illness can usually be avoided if treatment is administered in the incipient stage. The purpose of the infirmary is to help maintain the general good health of the students, as well as to furnish a suitable place for professional attention in cases of severe illness or accident.

General Fee.

4. The infirmary fee will be at the rate of $2 a day, and will be charged when one or more meals are obtained at the infirmary, or when the student remains at the infirmary for one or more nights. A nominal charge will be made to out-patients for miscellaneous treatment of a minor character.

Additional Expenses.

5. In addition to the fee charged, as specified in paragraph 4, the following additional expenses will be charged to the patient: —

(*a*) *Nurses.* — In case a special nurse is required for the proper care of an individual, the services and board of this nurse will be paid by the patient. Such a nurse will be under the general supervision of the resident nurse.

(*b*) *Professional Service.* — If a student requires medical attention by a physician, he will be required to select his physician and become responsible for fees charged by the physician.

(*c*) *Supplies.* — Special medical supplies prescribed by a physician or nurse will be charged to the patient.

(*d*) *Laundry.* — Expense for personal laundry incurred by students while in the infirmary will be charged to the individual student.

B. COLLEGE ACTIVITIES.

General Exercises.

Chapel exercises are held two mornings each week. On Thursday an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the president is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

Student Activities.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established in 1907. All students become members of the union by paying a small fee. In the fall and winter months the union gives a series of entertainments, free to students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of undergraduate conduct, and represents before the faculty the interests of the student body.

The Young Men's Christian Association is active both socially and religiously. A Catholic club has also been organized.

Intercollegiate and intermural athletic contests are held throughout the year in the leading sports, including football, baseball, track, hockey and basketball. The athletic board, composed of alumni, faculty and students, has charge of finances, schedules, and general policies governing athletics.

The musical clubs include an orchestra and a glee club. These give about a dozen concerts, usually followed by dancing, during the year, both in Amherst and on tour. A dramatic club, The Roister Doisters, present annually a revue and two plays, one in connection with the promenade and the other at commencement. There are, besides the declamation and oratorical prize contests, both underclass and intercollegiate debates. The college is a member of a triangular league with Rhode Island and Connecticut. The college publications are the "Massachusetts Collegian," the weekly newspaper; "The Index," the year book; "The Squib," a comic magazine; and "The Alumni Bulletin," issued from the office of the alumni secretary. The Academic Activities Board, composed of alumni, faculty and students, has charge of the finances, schedules, etc., of the various clubs and publications.

A rifle club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

C. ACADEMIC AND DEPARTMENTAL.

Degrees.

Those who complete a four-year course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10. Credit may sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-year course of study, and present a satisfactory thesis, will be granted the degree of doctor of philosophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest tenth of the senior class who have attained an average grade of at least 85 per cent during their college course.

Prizes.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1921 were: —

Agriculture. — The Grinnell prizes, given by Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, for excellence in theoretical and practical agriculture. Three prizes, $25, $15, $10. The contest is open to those senior students whose record on the registrar's books shows an average standing of 80 or above for the technical work taken in the Divisions of Agriculture and Horticulture during the junior and senior years.

Botany. — The Hills prizes, given by Henry F. Hills of Amherst, amount to $35 annually. Competition is open to members of the senior, junior and sophomore classes as follows: for the best herbarium, $20; for the second best herbarium, $15. No collection deemed unworthy of a prize will be considered.

Public Speaking. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declamations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, $30 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

Awards and Prizes, 1922.

Grinnell Prizes. — The Grinnell prizes, given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture, were awarded as follows: —

First prize, Richmond Edmund Field.

Second prize, Francis Sample Tucker.

Third prize, William Henry Peck.

Public Speaking. — The Burnham prizes were awarded to the students delivering the best and second best declamations, as follows: —

First prize, Alfred Porter Staebner, 1924.

Second prize, James Batal, 1925.

Flint Prizes. — The Flint prize was awarded to the student delivering the best oration, as follows: —

First prize, James Batal, 1925.

Second prize, Belding Francis Jackson, 1922.

Hills Prizes. — The Hills prizes for the best herbaria were awarded as follows: —

First prize, Danitza Arangelovitch, 1924.

Second prize, Samuel Henry White, 1924.

Southern Alumni Baseball Cup. — For the best all-round baseball player during the season of 1921 the Southern Alumni baseball cup was awarded to Julius Kroeck, Jr., 1922.

Allen Leon Pond Memorial Medal, for Excellence in Football. — The Allen Leon Pond memorial medal for general excellence in football was awarded to John Neptumcen Lewandowski, 1922. This medal is in memory of Allen Leon Pond of the class of 1920, who died Feb. 26, 1920.

Degrees Conferred and Roll of Students

Degrees Conferred—1922.

MASTER OF SCIENCE (M.Sc.).

Avery, Roy Crowdy, B.Sc., Connecticut Agricultural College	New York City.
Clark, Dorothy Porter, A.B., Wellesley College	Newton.
French, Rowland Barnes, B.Sc., Dartmouth College	Haverhill.
Nirody, Bhavani Sankarrao, B.A., University of Madras	Madras, India.

DOCTOR OF PHILOSOPHY (PH.D.).

Hood, Egerton Gibson, B.S.A., Ontario Agricultural College (Toronto University)	Macdonald College, Quebec, Can.
Neill, James Maffett, B.Sc., Allegheny College	Clarion, Pa.

BACHELOR OF SCIENCE (B.Sc.).

Acheson, Roger Melvin	New Bedford.
Andrews, John Hollis	Vineyard Haven.
Bainton, Hubert Judson	Hyde Park.
Baker, George Louis	Amherst.
Barnard, Kenneth Allen	Shelburne.
Beckwith, Robert Henry	Pittsfield.
Bent, Leslie Dana	Medfield.
Blakely, Roger Wolcott	Medford.
Blanchard, Raymond Stanwood	Wollaston.
Bromley, Stanley Willard	Southbridge.
Buck, Charles Alfred	Mansfield.
Burnett, Paul Lapham	Leicester.
Burnham, Edwin Graham	Springfield.
Calhoun, Salteau Frederick	Brookline.
Carey, Edmund Thomas	Springfield.
Chapin, Ellis Warren, Jr.	Chicopee Falls.
Chase, Eleanor Frances	Amesbury.
Clark, Clarence Frederick	Sunderland.
Collins, Herbert Laurence	Arlington.
Conant, Luman Binney	Waltham.
Cotton, George Asa	Woburn.
Crawford, Alexander George	Waverley.
Davis, Harold Sanborn	Belchertown.
Degener, Otto	New York, N. Y.
Dwyer, James Edward	Sunderland.
Erysian, Harry Adrian	Chelsea.
Field, Richard Edmund	Shelburne Falls.
Freeman, Stanley Leonard	Needham.
Gilbert, Frank Albert, Jr.	Brandon, Vt.
Gore, Jane Isabel Pollard	North Adams.
Gowdy, Carlyle Hale	Westfield.
Haskins, Philip Hall	North Amherst.
Higgin, Albert Snyder	Baltimore, Md.
Hodgson, Robert Moore	Boston.
Holman, Reginald Newton	Somerville.
Hooper, Francis Edwards	Revere.
Hurder, Ruth Wasson	Milton.

Hussey, Francis William	Whitinsville.
Jackson, Belding Francis	Belchertown.
Jordan, Raymond Douglas	Springfield.
Kemp, George Austin	North Andover.
Knapp, Irving Robinson	Seekonk.
Kokoski, Frank Joseph	Amherst.
Krasker, Abraham	Revere.
Kroeck, Julius, Jr.	Huntington, L. I., N. Y.
Lacroix, Donald Sewall	Rowley.
Lal, Prem Chand	India.
Law, Hervey Fuller	Longmeadow.
Lawrence, Robert Parker	East Greenwich, R. I.
Leland, James Freeman, Jr.	Sherborn.
Leonard, Earle Stanley	Hyde Park.
Lewandowski, John Neptumcen	Easthampton.
Lindquist, Harry Gotfred	Holden.
Lovering, Everett Waldron	Northampton.
Lovering, Rolland Frederick	Northampton.
Lowery, John Gordon	Malden.
Lyons, Edgar Albion	Methuen.
Lyons, John Joseph, Jr.	Arlington.
MacArdle, Herbert Aloysius	Worcester.
Main, Stuart DeGroff	Maplewood, N. J.
Martin, Edward William	Amherst.
McGuinn, Albert Francis	Worcester.
McNulty, Raymond Henry	North Brookfield.
Moody, Kenneth Watts	Brookline.
Moseley, Henry Samson	Glastonbury, Conn.
Murdock, Matthew John	Medford.
Murray, Harry Athol, Jr.	Arlington.
Murray, Myron George	Bradford.
Nigro, Henry	Revere.
Packer, George Blanchard	Woodbury, Conn.
Peck, William Henry	Stow.
Perry, Helen Margaret	Waltham.
Pickup, Ezra Alden	Holyoke.
Randall, Kenneth Charles	Springfield.
Reed, Paul Malcolm	Baldwinville.
Richardson, Marjory	Millis.
Rollins, Walter Jessie	Leominster.
Roser, Conrad Herman	Glastonbury, Conn.
Russell, Ralph	Worcester.
Shaughnessy, Howard John	Amherst.
Smith, Albert William	Easthampton.
Smith, Rowland Piper	North Amherst.
Spring, Hobart Wadsworth	Braintree.
Stevens, Ralph Shattuck	Arlington.
Sullivan, Joseph Timothy	Lawrence.
Swift, Arthur Lawrence	North Amherst.
Talmage, Harry John	Springfield.
Tanner, Willis	Worcester.
Task, Mortimer	West Stoughton.
Thompson, George Henry, Jr.	Lenox.
Tucker, Francis Sample	Arlington.
Vinten, Charles Raymond	Roxbury.
Walker, Philip Duane	Hardwick.
Warren, Edwin Herbert	Chelmsford.
Waugh, Frederick Vail	Amherst.
Weber, Harold Richard	Brooklyn, N. Y.
Wentsch, Harold Earle	Worcester.
Whitaker, Carl Fales	Hadley.
White, George Edwin	Worcester.
Wood, Clarence Milton	West Somerville.

Registration, 1922–23.

As of November 1, 1922.

Graduate Students.

Ali, Mehmed . . . . Smyrna, Asia Minor.
B.A., International College, Smyrna.
Archibald, John G. . . . . Amherst.
B.S.A., Ontario Agricultural College, Toronto University.
Avery, Roy C. . . . . Amherst.
B.Sc., Connecticut Agricultural College.
Bonnell, Anna V. . . . . Elizabeth, N. J.
A.B., Mount Holyoke College.
Brase, Herman H. . . . . Longmeadow.
B.A., New York University.
Bromley, Stanley W. . . . . Southbridge.
B.Sc., Massachusetts Agricultural College.
Buchanan, Walter G. . . . . Bernardston.
B.Sc., Massachusetts Agricultural College.
Campbell, Walter J. . . . . Springfield.
A.B., M.A., Princeton University.
Chao, Chung-ting . . . . Nanking, China.
B.Sc., College of Agriculture, University of Nanking.
Chase, Eleanor F. . . . . Amesbury.
B.Sc., Massachusetts Agricultural College.
Dickinson, Lawrence S. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Dooley, Thomas P. . . . . Dorchester.
B.Sc., Massachusetts Agricultural College.
Epstein, Nathan I. . . . . Salem.
B.Sc., Massachusetts Institute of Technology.
Flikkema, Renzy E. . . . . Morrison, Ill.
A.B., Hope College.
Flint, Oliver S. . . . . Amherst.
B.S., Massachusetts Agricultural College.
Frellick, Ralph S. . . . . Everett.
B.Sc., Franklin College.
French, Arthur P. . . . . Amherst.
B.Sc., Ohio State University.
Garvey, Mary E. M. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Glover, Theodore W. . . . . North Easton.
B.Sc., Massachusetts Agricultural College.
Godbout, J. Adelard . . . . Ste. Anne de la Pocatiere, P. Q., Can.
B.Sc., B.S.A., École d'Agriculture de Ste. Anne de la Pocatiere.
Hall, Merwin P. . . . . Brookline.
A.B., Amherst College.
Harris, Roy D. . . . . Amherst.
B.Sc., Middlebury College.
Higgin, Albert S. . . . . Passaic, N. J.
B.Sc., Massachusetts Agricultural College.
Hodgdon, Julia P. . . . . Hannibal, Mo.
B.A., Smith College.

Johnson, John F. . . . . Mount Airy, N. C.
B.S., North Carolina State College.
Julian, Arthur N. . . . . Amherst.
B.A., Northwestern University.
Lanphear, Marshall O. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Lowe, C. Hiram . . . . Chinwangtao, North China.
B.A., Pekin University.
B.Sc., University of Illinois.
Mack, Warren B. . . . . Amherst.
Ph.B., Lafayette College.
McCrimmon, John G. . . . . Williamstown, Ontario, Can.
B.S.A., Ontario Agricultural College, Toronto University.
Merritt, L. A. . . . . Williamsburg.
B.Sc., Trinity College.
Meserve, Charles A. . . . . Livermore Falls, Me.
B.Sc., Massachusetts Institute of Technology.
Ph.D., University of Erlangen, Bavaria.
Mooney, Raymond A. . . . . Plattsburg, N. Y.
B.Sc., Massachusetts Agricultural College.
Morgan, Ezra L. . . . . Columbia, Mo.
A.B., McKendree College.
M.A., University of Wisconsin.
Morin, Adrien . . . . St. Celestin, P. Q., Can.
B.S.A., École d'Agriculture de Ste. Anne de la Pocatiere.
Muller, Richard T. . . . . Amherst.
B.S., Cornell University.
M.S., University of Maine.
O'Brien, Daniel W. . . . . Natick.
B.Sc., Massachusetts Agricultural College.
Parker, J. R. . . . . St. Paul, Minn.
B.Sc., Massachusetts Agricultural College.
Potter, David . . . . Concord.
B.Sc., Massachusetts Agricultural College.
Rice, Victor A. . . . . Amherst.
B.Sc., North Carolina State College.
Robertson, William F. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Rogers, Roland W. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Sanborn, Joseph R. . . . . North Amherst.
B.Sc., Massachusetts Agricultural College.
Serex, Paul, Jr. . . . . Amherst.
B.Sc., M.Sc., Massachusetts Agricultural College.
Snyder, Grant B. . . . . Amherst.
B.S.A., Ontario Agricultural College, Toronto University.
Thelin, Guy . . . . Amherst.
B.Sc., South Dakota State College.
Tietz, Harrison M. . . . . Richmond Hill, N. Y.
B.Sc., Massachusetts Agricultural College.
Tipple, Esther W. . . . . Valparaiso, Ind.
B.S., Teachers College, Columbia University.
Verder, Bessie C. . . . . Lyndon Center, Vt.
B.S., Middlebury College.
M.A., Brown University.
Vinten, Charles Raymond . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
West, Guy C. . . . . Amesbury.
B.Sc., Massachusetts Agricultural College.
Willard, John D. . . . . Amherst.
B.A., Amherst College.
Worthley, Harlan N. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Yount, Hubert W. . . . . Toledo, Ohio.
B.Sc.Agr., Ohio State University.

Registered after the Catalogue for 1921 was published.

Conant, Luman B. . . . . Waltham.
B.Sc., Massachusetts Agricultural College.
Dickinson, Lawrence S. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
French, Willard K. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Gore, Jane Pollard . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Haskins, Harold A. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Lanphear, Marshall O. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Lindsey, Joseph B., Jr. . . . . Amherst.
A.B., Dartmouth College.
Mack, Warren B. . . . . Amherst.
Ph.B., Lafayette College.
Maginnis, John J. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
Muller, Richard T. . . . . Amherst.
B.S., Cornell University.
M.S., University of Maine.
Perry, Helen Margaret . . . . Waltham.
B.Sc., Massachusetts Agricultural College.
Richardson, Marjory . . . . Millis.
B.Sc., Massachusetts Agricultural College.
Robinson, Philip L. . . . . South Dartmouth.
B.Sc., Massachusetts Agricultural College.
Sawtelle, Donald W. . . . . Amherst.
B.S., University of Maine.
Stowell, Harold T. . . . . Hathorne.
B.Sc., Massachusetts Agricultural College.
Tanner, Willis . . . . Worcester.
B.Sc., Massachusetts Agricultural College.
Von Mechow, Herbert L. . . . . Bellmore, N. Y.
B.S.A., Syracuse University.
Wallace, Anna M. . . . . Amherst.
A.B., Smith College.
A.M., Yale Graduate School.
Waugh, Frederick V. . . . . Amherst.
B.Sc., Massachusetts Agricultural College.
West, Guy C. . . . . Amesbury.
B.Sc., Massachusetts Agricultural College.
Willard, John D. . . . . Amherst.
B.A., Amherst College.

Class of 1923.

Abele, Trescott Tupper	Quincy	Theta Chi.
Alexander, Donald Briggs	Boston	Sigma Phi Epsilon.
Alger, Mason Williams	West Bridgewater	Alpha Gamma Rho.
Arrington, Luther Bailey	Florence	Alpha Gamma Rho.
Baker, Howard	Marshfield	Sigma Phi Epsilon.
Bateman, Eleanor Willard	Arlington Heights	Abigail Adams House.
Bates, Howard	Cohasset	Kappa Gamma Phi.
Bates, Robert Brooks	West Springfield	Alpha Gamma Rho.
Beal, James Allen	Abington	Kappa Sigma.
Bennett, James Stanley	South Meriden, Conn.	Alpha Gamma Rho.
Boles, Inza Almena	Dorchester	Abigail Adams House.
Borgeson, Melvin Benjamin	Auburn	Kappa Gamma Phi.
Brewer, Gardner Hunter	Upton	Kappa Epsilon.
Broderick, Lawrence Francis	Hyde Park	17 North College.
Buckley, Francis Edward	Natick	Kappa Sigma.
Burbeck, Joseph Howard	Peabody	Sigma Phi Epsilon.

Burke, Edmund William	Watertown	Kappa Epsilon.
Cohen, Solomon	Dorchester	15 North College.
Collins, Donald Keith	Rockland	Theta Chi.
Cook, Frederick Belcher	Niantic, Conn.	Kappa Epsilon.
Corash, Paul	Worcester	14 South College.
Dickinson, Lewis Everett, Jr.	Holyoke	Kappa Epsilon.
Dowden, Philip Berry	Sandwich	Sigma Phi Epsilon.
Faneuf, John Benedict	West Warren	Kappa Epsilon.
Fitzpatrick, Leo Joseph	Brockton	North College.
Folsom, Owen Eugene	Roslindale	Phi Sigma Kappa.
Friend, Roger Boynton	Dorchester	Alpha Gamma Rho.
Fuller, Robert Donald	Woburn	Q. T. V.
Gamzue, Benjamin	Holyoke	13 South College.
Gerry, Bertram Irving	Peabody	Alpha Gamma Rho.
Gildemeister, Mary Katherine	Belchertown	Abigail Adams House.
Giles, Clifton Forrest	Newtonville	Sigma Phi Epsilon.
Gold, Philip	Lynn	13 South College.
Goldstein, Joseph	Lynn	14 South College.
Gordon, Howard Reynolds	Ipswich	Lambda Chi Alpha.
Graves, George	Granville, Ohio	Theta Chi.
Grayson, Raymond Henry	Milford	Alpha Sigma Phi.
Hale, John Stancliff	South Glastonbury, Conn.	Phi Sigma Kappa.
Hallett, Melvin Bernard	Rockland	Theta Chi.
Harrington, Robert John	Holyoke	Alpha Sigma Phi.
Heath, Allan Jay	Newfane, Vt.	Kappa Epsilon.
Hilyard, Norman Douglas	Beverly	Q. T. V.
Hodsdon, Marshall Sinclair	Melrose Highlands	Phi Sigma Kappa.
Holley, George Gilbert	Fiskdale	Lambda Chi Alpha.
Hollis, Frederick Allen	Charlton	French Hall.
Hunter, Henry Leander, Jr.	Pleasantville, N. Y.	Theta Chi.
Irish, Gilbert Henry	Turner, Me.	Lambda Chi Alpha.
Johnson, Cleon Bancroft	Ipswich	Kappa Epsilon.
Johnson, Eyrle Gray	Mattapan	Lambda Chi Alpha.
Lewis, Molly LeBaron	Jamaica Plain	Abigail Adams House.
Lindskog, Gustaf Elmer Richard	Roxbury	Clark Hall.
Luddington, Frank Dennison	Hamden, Conn.	17 North College.
MacCready, Donald Eugene	Elizabeth, N. J.	Phi Sigma Kappa.
Marshall, Alexander Borea	Greenwich, Conn.	Theta Chi.
Marshman, Wilbur Horace	Springfield	Kappa Sigma.
Martin, Frances Barbara	Amherst	5 Phillips Street.
Martin, Robert Fitz-Randolph	Amherst	Amherst House.
Mather, Edna	Amherst	5 Allen Street.
Minor, John Bacon, Jr.	Amherst	70 Lincoln Avenue.
Mohamedi, Sageer	India	14 North College.
Mohor, Robert deSales	Newton Center	Phi Sigma Kappa.
Mudgett, Vernon Downer	Brookline	Lambda Chi Alpha.
Newell, Richard Carll	West Springfield	Alpha Gamma Rho.
Norcross, Harry Cecil	Brimfield	16 South College.
Nowers, Donald Gilford	Danvers	Lambda Chi Alpha.
Paddock, Wallace Earl	Worcester	Farmhouse.
Picard, Charles Francis	Plymouth	17 North College.
Putnam, Ernest Taylor	Greenfield	Kappa Epsilon.
Richardson, Mark Morton	West Brookfield	11 South College.
Roberts, Arthur William	Hyde Park	Theta Chi.
Russell, Charles Francis	Winchendon	46 Pleasant Street.
Sandow, Alexander	Pittsfield	13 South College.
Sargent, Richmond Holmes	Winthrop, Me.	Kappa Sigma.
Sears, Fred Grant, Jr.	Dalton	Phi Sigma Kappa.
Sharpe, Charles Gertner	Amherst	13 Paige Street.
Shea, Thomas Francis	Holyoke	Kappa Gamma Phi.
Slade, Irving Woodman	Chelsea	Kappa Sigma.
Smith, Jeffrey Poole	West Roxbury	North College.
Snow, Thomas Lathrop	Greenfield	Alpha Gamma Rho.
Tanner, Edwin	Worcester	North College.

Tarr, James Gordon	Gloucester	Sigma Phi Epsilon.
Tisdale, Edward Norman	Medfield	Lambda Chi Alpha.
Towne, Carroll Alden	Auburndale	Q. T. V.
Towne, Warren Hannaford	Cambridge	Kappa Epsilon.
Tumey, Malcomb Edward	Deerfield	Q. T. V.
Turner, Dorothy VanHoven	Washington, D. C.	Abigail Adams House.
Wendell, Richard Goodwin	Belmont	Phi Sigma Kappa.
Whitaker, Holden	Newton Highlands	The Davenport.
Whittier, John McKey	Brookline	Kappa Sigma.
Williams, Forrest Earl	Sunderland	Q. T. V.
Wirth, Conrad Louis	Minneapolis, Minn.	Kappa Sigma.

Class of 1924.

Barrows, Robert Arthur	Quincy	Lambda Chi Alpha.
Bartlett, Frederick Sheldon	Westfield	Sigma Phi Epsilon.
Bartlett, Perry Goodell	Holyoke	Lambda Chi Alpha.
Bartlett, Warren Leslie	Boston	Phi Sigma Kappa.
Belden, Clifford Luce	Bradstreet	Kappa Sigma.
Bike, Edward Louis	Westfield	Sigma Phi Epsilon.
Bittinger, Richard	Northfield	Sunset Avenue, care of Professor Banta.
Bowes, Charles Atwell	Worcester	Q. T. V.
Brunner, Fred, Jr.	New York, N. Y.	Phi Sigma Kappa.
Cahalane, Victor Harrison	Charlestown, N. H.	83 Pleasant Street.
Carpenter, Earle Stanton	Rehoboth	Alpha Sigma Phi.
Chase, Theodore Martin	Livermore Falls, Me.	Phi Sigma Kappa.
Cromack, Earl Augustus	Shelburne Falls	Theta Chi.
Darling, Robert Martin	Cambridge	Q. T. V.
Davis, Howard Halsey	Brockton	Lambda Chi Alpha.
Deuel, Charles Frederick, 2d	Amherst	Q. T. V.
Dimock, Walter Lewis	Oxford	11 South College.
Dresser, Allen Lucius	Amherst	Q. T. V.
Elliott, James Alexander	Summit, N. J.	Care of Geo. Cooley, Sunderland.
Emery, George Edward	Marlborough	Sigma Phi Epsilon.
Epps, Martha Belle Scott	Winchendon	Abigail Adams House.
Fenton, John Michael	Amherst	108 Pleasant Street.
Fernald, Leland Hoyt	Arlington	Lambda Chi Alpha.
Flint, Ruth Guild	Allston	Abigail Adams House.
Foley, Mary Joanna	Worcester	Abigail Adams House.
Frost, Sherman Clark	Cambridge	Sigma Phi Epsilon.
Frost, Willard Chamberlain	Milford	Theta Chi.
Gadsby, James Herbert	North Adams	Q. T. V.
Garretson, Alfred Corwin	Bound Brook, N. J.	Phi Sigma Kappa.
Gay, Alfred Fullick	Groton	Theta Chi.
Geiger, Aimee Suzanne	Pepperell	Abigail Adams House.
Gifford, Richard Smith	South Westport	Sigma Phi Epsilon.
Goldsmith, Eliot Gray	Brookline	Kappa Sigma.
Grieve, Alexander Watson	Dorchester	Alpha Gamma Rho.
Gryzwacz, Patrick Louis	Ware	The Davenport.
Haskell, Malcolm Rawson	Amherst	Kappa Sigma.
Hayden, Luther Leonard, Jr.	Brookville	Stockbridge Hall.
Hill, Carroll Victor	Worcester	1 Allen Street.
Holway, Clarence Warren	Putney, Vt.	12 South College.
Hubbard, Doris	Newton	Abigail Adams House.
Isaac, Carl Frederick	Brighton	Alpha Gamma Rho.
James, Locke LeBaron	West Bridgewater	Alpha Gamma Rho.
Kane, Edward Anthony	Westfield	Q. T. V.
Keith, Clifford Woodworth	Providence, R. I.	Theta Chi.
Kennedy, Lowell Francis	Cambridge	Q. T. V.
King, Rosewell Howard	Millville	Alpha Sigma Phi.
Lamb, Eric Franklin	Waban	Theta Chi.
Lane, Wilfred Craig	Fitchburg	Kappa Gamma Phi.

Leland, Allen Sanford	East Bridgewater	40 Sunset Avenue.
Loring, Kenneth Stockwell	Melrose Highlands	Lambda Chi Alpha.
Miller, Edwin Clark	Northampton	354 Bridge Street, Northampton.
Morris, Walter Markley	Amherst	44 Triangle Street.
Myrick, Sterling	Longmeadow	16 South College.
Nelson, Carl Olaf	Gloucester	Alpha Gamma Rho.
Nicoll, Arthur Chester	Quincy	Lambda Chi Alpha.
Norwood, Howard Lester	Boston	101 Butterfield Terrace.
Noyes, Russell	Newton Centre	Theta Chi.
Pearson, John Cleary	Cambridge	116 Pleasant Street.
Percival, Gordon Pittinger	Medfield	3 North College.
Perry, Chauncy Valentine	Waltham	Theta Chi.
Pierce, Arthur Edwin	Newton	Phi Sigma Kappa.
Porges, Nandor	Hyde Park	9 South College.
Pratt, Wallace Francis	Rockland	Alpha Gamma Rho.
Read, John Gammons	Springfield	Alpha Sigma Phi.
Regan, Leon Ashley [1]	Walpole	7 North College.
Reynolds, Joseph Sagar	Attleboro	Experiment Station Barn.
Rhodes, Winthrop Gordon	Waban	Theta Chi.
Ricker, Chester Sewall	Worcester	Alpha Sigma Phi.
Rowell, Elwyn Joseph	Amherst	44 Triangle Street.
Salman, Kenneth Allen	Needham	Aggie Inn.
Schaffer, Carlton Hill	Ashfield	3 North College.
Sellers, Wendell Folsom	Melrose	Alpha Gamma Rho.
Shepard, Harold Henry	South Royalston	Physics Building.
Sims, Kenneth Wallace	South Boston	Alpha Gamma Rho.
Smith, Richard Burr	Greenfield	Phi Sigma Kappa.
Staebner, Alfred Porter	Willimantic, Conn.	Kappa Sigma.
Steele, Charles Wasser	Marblehead	Lambda Chi Alpha.
Steere, Robert Ernest	Chepachet, R. I.	103 Pleasant Street.
Stevenson, Harold Dudley	Camden, Me.	Alpha Gamma Rho.
Tewhill, Charles James	Florence	Alpha Gamma Rho.
Thornton, Clarence Percy	Pelham	Amherst, R. F. D. 2.
Tobey, Charles Sylvester	Belmont	Phi Sigma Kappa.
Varnum, Thomas, Jr.	Lowell	Phi Sigma Kappa.
Walker, Judson Newcombe	Marlboro, N. H.	31 East Pleasant Street.
Waugh, Albert Edmund	Amherst	Kappa Sigma.
Weatherwax, Howard Erle	Greenfield	Theta Chi.
White, Samuel Henry	Orange	Lambda Chi Alpha.
Whitman, Chester Edgerly	Milton, N. H.	Phi Sigma Kappa.
Whitney, Richard Augustine	Brooklyn, N. Y.	Kappa Sigma.
Whitney, Will Alvah	Taunton	3 North College.
Williams, James Lowell	Sunderland	Q. T. V.
Witt, Earl Maynard	Belchertown	Alpha Gamma Rho.
Wood, Ruth Millicent	North Andover	Abigail Adams House.
Wood, William Wilson	Barre Plains	51 Amity Street.
Woodworth, Robert Hugo	Newton	Phi Sigma Kappa.

Class of 1925.

Armstrong, Bradford	Kensington, Md.	Q. T. V.
Atkins, Harold Kent	Wollaston	Sigma Phi Epsilon.
Barnes, Adrian Douglas	South Weymouth	Q. T. V.
Batal, James	Lawrence	President's House.
Bean, Francis Irving	Bradford	35 East Pleasant Street.
Benoit, Helen Anna	Amherst	16 Belchertown Road.
Binner, Roger Stokehill	Amherst	29 Northampton Road.
Blanchet, Earl Oliver	Northampton	34 Fruit Street, Northampton.
Bray, Ralph Hastings	Framingham	Sigma Phi Epsilon.
Burhoe, Sumner Othniel	Ashland	21 Fearing Street.

[1] Special junior.

Cahill, Carl Winfield	Newburyport	Kappa Sigma.
Casey, Alice Rita	Fall River	Abigail Adams House.
Cassano, Joseph [1]	Groveland	Q. T. V.
Church, George Lyle	Dorchester	5 Farview Way.
Cleaves, Leighton Greenwood	Gardner	Phi Sigma Kappa.
Cooke, Robert Gordon	Richmond	Alpha Sigma Phi.
Corwin, Emil Joseph	East Boston	6 Phillips Street.
Crosby, John Samuel	Arlington	Phi Sigma Kappa.
Currier, Leland Little	Marblehead	Alpha Gamma Rho.
Davis, Osborne Ozro	Belchertown	20 South College.
Dean, Lecil Wallace	West Palm Beach, Fla.	16 North College.
DeVito, Dominick	Roxbury	Kappa Epsilon.
Duffy, Leo Francis [2]	Springfield	Kappa Epsilon.
Farrington, Linwood Henry	Chelmsford	13 Phillips Street.
Ferranti, Edmund Tony	West Bridgewater	Lambda Chi Alpha.
Fish, Donald Otis	Amherst	12 Hallock Street.
Gilbert, Chauncey McLean [2]	North Amherst	North Amherst.
Gleason, Harold Albert	Chester	Care of Mr. Everson.
Gordon, Solomon	Boston	9 South College.
Grout, Helen Myra	Gill	7 Allen Street.
Grover, Walter Champion	Bernardston	Phi Sigma Kappa.
Guterman, Carl Edward Frederick	Springfield	Kappa Sigma.
Haeussler, Gilbert Julius	Springfield	Kappa Sigma.
Hale, Laurence Newton	South Glastonbury, Conn.	Phi Sigma Kappa.
Hanscombe, George Wilmont	North Attleborough	2 North College.
Harris, Clarence Albert	Utica, N. Y.	3 McClellan Street.
Hopkins, David	Amherst	17 Phillips Street.
Hurley, Everett Henry	Northampton	Sigma Phi Epsilon.
Hyde, John Worthington	Amherst	55 Pleasant Street.
Ingraham, Edward Forster	Millis	Sigma Phi Epsilon.
Jack, Melvin Clifton	Amherst	16 Hallock Street.
Kakavas, James Christo	Lowell	9 Fearing Street.
Keith, Lewis Hayden	Bridgewater	Kappa Sigma.
Kilbourn, James Sheldon	Pittsfield	Sigma Phi Epsilon.
Lacey, John Sebastian	Holyoke	13 Elm Street, Holyoke.
Lavallee, Louis Palmer	Worcester	5 Nutting Avenue.
Lewis, Donald Walter	Stow	10 South College.
Logan, Hazel Wayne	Brockton	Care of Mrs. Chamberlain, Mount Pleasant.
Lord, John Frederic	Methuen	Alpha Sigma Phi.
Love, Andrew Wyllie	Auburn	11 North College.
Lunt, Samuel Wilde	West Falmouth, Me.	Kappa Sigma.
MacAfee, Norman Hoar	Cambridge	Alpha Gamma Rho.
Mahoney, Walter Francis	Millville	Alpha Sigma Phi.
Marx, Herbert John	Holyoke	10 South College.
McGeoch, Charles Ryerson	Providence, R. I.	North College.
McGrath, Thomas Edmund	Holyoke	Baker Place.
Meserve, George Donald	Hudson	Lambda Chi Alpha.
Mouradian, Garabed Kevork	Bridgewater	Q. T. V.
Moxon, David	Holyoke	10 South College.
Nelson, Paul Redfield	Holyoke	84 Pleasant Street.
O'Connor, Arthur Maxwell	Amherst	Mount Pleasant.
Oliver, Charles Frank, Jr.	Brockton	2 North College.
Parker, Donald Llewellyn	North Adams	Sigma Phi Epsilon.
Parsons, James Gilbert	Melrose Highlands	Baker Place.
Peirce, Veasey	Dorchester	Phi Sigma Kappa.
Peltier, Xavier Paul	Spencer	West Experiment Station.
Perry, John Tuttle	Waltham	25 Gray Street.
Poey, Frederick	Boston	Alpha Sigma Phi.
Root, Frank Edson	Bernardston	Alpha Gamma Rho.
Ross, Charles Frederick	Lee	Sigma Phi Epsilon.
Ross, Donald Ernest	Amherst	23 Woodside Avenue.

[1] Special sophomore. [2] Probation entrance.

Rowley, Harold Frederick	West Wareham	15 Hallock Street.
Samuels, Samuel Bernhard	Bronx, N. Y.	14 South College.
Sazama, Robert Francis	Northampton	19 Arlington Street, Northampton.
Seaver, Russell Bradford	South Hanson	M. A. C. Bungalow.
Sheridan, Irwin Scott	Mansfield	Alpha Gamma Rho.
Shumway, George Francis	Monson	21 Fearing Street.
Simmons, Carl Lafayette	Kingston	West Experiment Station.
Simpson, Gilbert	Holyoke	8 Allen Street.
Slowen, William Arnold	Shelburne Falls	13 Phillips Street.
Smith, Emily Greenwood	Lee	Abigail Adams House.
Sprague, Dudley deRochemont	Melrose	16 South College.
Stephan, Edith Helen	Lawrence	16 Pleasant Street.
Stone, George Leroy	Montello	Clark Hall.
Taube, Gustave	New York, N. Y.	9 South College.
Taylor, Milton Wight	Chatham	Kappa Sigma.
Templeton, Robert James	Boston	2 North College.
Tufts, Robert Warner	North Weymouth	Kappa Gamma Phi.
Ward, Gordon Hugh	Englewood, N. J.	Farmhouse.
White, Earl Martin	Abington	Kappa Sigma.
Whittum, Walter Willard	Springfield	Kappa Gamma Phi.
Wilcox, Stanley Dewey	Springfield	Kappa Gamma Phi.
Wilder, Frank Harris	Sterling	Phi Sigma Kappa.
Wilhelm, George Henry	Holyoke	Alpha Sigma Phi.
Woodbury, Samuel Lawrence	Springfield	Alpha Gamma Rho.
Wright, Horace Alfred	Dayton, Ohio	66 Pleasant Street.
Zwisler, Frederick Fisher	Holyoke	16 North College.

Class of 1926.

Adams, Kathleen Poland	Worcester	Abigail Adams House.
Aguilera, Leopoldo Sanchez	Havana, Cuba	Amherst Tavern.
Albertini, Paul Flanders	Billerica	6 Nutting Avenue.
Aldrich, George Sidney	Millville	Alpha Sigma Phi.
Ames, Winthrop Ashley	Vineyard Haven	32 North Prospect Street.
Amsden, Festus Gilbert	Athol	3 Allen Street.
Amsden, Theodore Maxwell [1]	Athol	3 Allen Street.
Anderson, Leslie Clayton	East Bridgewater	Farmhouse.
Anthony, Stewart Holmes	Manchester, N. H.	81 Pleasant Street.
Ashe, Thomas Edmond	Holyoke	12 North College.
Avery, Clifford Walter [2]	Colrain	53 Lincoln Avenue.
Backus, Hiram Heyworth	Centerville	6 Nutting Avenue.
Baker, Francis Everett	Hopkinton	Care of Mr. Everson.
Baker, Frederic Allen	Springfield	6 Nutting Avenue.
Barber, Elmer Everett	Jamaica Plain	27 Fearing Street.
Barnes, Russell Norris	Wallingford, Conn.	9 Mount Pleasant.
Bartlett, Herbert Franklin	West Springfield	30 North Prospect Street.
Beem, Merrill Adelbert	Portland, Me.	10 Woodside Avenue.
Belmore, George Alfred	Bridgewater	116 Pleasant Street.
Berry, George Robert	Northampton	33 Northampton Road.
Block, Harry William	Arlington	56 Pleasant Street.
Bosworth, Marguerite Rose	Holyoke	Abigail Adams House.
Bosworth, Maude Elinor	Holyoke	Abigail Adams House.
Bower, James, Jr.	Holyoke	5 North College.
Boyd, Mary Turck	Jacksonville, Fla.	Abigail Adams House.
Brougham, Earl Gordon	Holyoke	9 North College.
Brownell, Abbott Francis	New York, N. Y.	6 Allen Street.
Bruorton, Earle Wallace	Reading	9 Phillips Street.
Buckhout, Robert Cushman	South Hadley	83 Pleasant Street.
Buckley, Arthur Vincent	Natick	35 North Prospect Street.
Budge, William Karl	Mattapan	7 North College.

[1] Admitted on probation, entrance record incomplete.

[2] Special freshman.

Burnham, James Erastus [1]	Springfield	84 Pleasant Street.
Burrell, Robert Wallace	Abington	3 Allen Street.
Burt, Oren Clark, Jr.	Easthampton	Alpha Sigma Phi.
Burt, Stanley Lyman	Easthampton	4 Nutting Avenue.
Carlson, Oscar Ernest [1]	Amherst	66 Pleasant Street.
Cassidy, Marion Stewart	East Boston	Abigail Adams House.
Clarke, Lawrence Gahn	Stoneham	McClure Street.
Clarke, Russell James	Stoneham	McClure Street.
Clough, Harry Elias	Ashburnham	31 North Prospect Street.
Collier, William Wellington	Hopedale	83 Pleasant Street.
Cook, Wendell Burnham	Townsend	31 East Pleasant Street.
Cooke, Helen Beatrice	Richmond	Abigail Adams House.
Cormier, Francis Joseph [1]	Newtonville	8 Allen Street.
Couhig, Philip Henry	Beverly	Q. T. V.
Cromack, Aaron Field	Shelburne Falls	Experiment Station.
Cutler, Samuel	Springfield	75 Pleasant Street.
Davenport, Preston Julian [2]	Shelburne Falls	53 Lincoln Avenue.
Davis, Evelyn Louise	Springfield	Abigail Adams House.
Dick, Ernest Albert	Lawrence	29 Lincoln Avenue.
Dimock, Harold Edgar	Oxford	15 South College.
Dodge, Eliot Perkins	Beverly	12 Chestnut Street.
Donoghue, Claire Eileen	Holyoke	Abigail Adams House.
Doolittle, Alden Hartwell	Northfield	116 Pleasant Street.
Douglass, Earle Lawrence	Springfield	15 Phillips Street.
Dow, Philip Norman	Bolton	Farmhouse.
Ducharme, Lucien Henry	Holyoke	7 Nutting Avenue.
Eldredge, Stuart	Winchester	Kappa Sigma.
Estabrook, William Warren	Brimfield	4 Nutting Avenue.
Fairbanks, Sumner Cushman	Norwood	1 North College.
Farley, Elizabeth	Amherst	61 Amity Street.
Fessenden, Richard William	Middleborough	Mount Pleasant.
Fitzgerald, Lillian Alice	Holyoke	Abigail Adams House.
Flynn, Alan Foster	Newton	North College.
Ford, William Warner	Dalton	9 Phillips Street.
Fraser, Carl Arthur	Westborough	3 Nutting Avenue.
Fraser, Harry Edward	Jamaica Plain	7 North College.
Fuller, George Leonard	Haydenville	33 Northampton Road.
Gaskill, Peter Carl	Worcester	7 Nutting Avenue.
Gavin, Linus Arthur	Natick	35 North Prospect Street.
Goodwin, Frederick Tucker	Westfield	15 Phillips Street.
Goodwin, Marvin Warren	Reading	6 Nutting Avenue.
Gordon, Samuel Francis	Ipswich	Lambda Chi Alpha.
Goren, Louis	Chelsea	56 Pleasant Street.
Gould, Ralph Otis	Topsfield	17 Kellogg Avenue.
Grant, Theodore James	Auburndale	11 South College.
Grayson, Herbert	Milford	83 Pleasant Street.
Greenwood, Elliott Kelton	Hubbardston	Farmhouse.
Griswold, Hugh Tower	Griswoldville	53 Lincoln Avenue.
Guild, Everett Joseph	Melrose Highlands	10 North College.
Gustafson, Alton Herman	Brockton	18 Nutting Avenue.
Harris, Stephen Fitch	Brookline	5 Fearing Street.
Hart, Ralph Norwood	Dorchester	5 Farview Way.
Hatch, Harold Curtis [1]	Melrose	8 Kellogg Avenue.
Haynes, Walter Lincoln	Springfield	53 Lincoln Avenue.
Heald, Theodore Boyd	Amherst	73 Northampton Road.
Henneberry, Thomas Vincent	Manchester	8 North College.
Hines, Oliver Clayton [1]	Everett	47 Pleasant Street.
Holbrook, Lester Morse	Fairhaven	16 South College.
Hollingworth, Duncalf Wright	Providence, R. I.	66 Pleasant Street.
Hopkinson, Howard	Holyoke	Amherst Tavern.
Horner, David James	Montpelier, Ohio	29½ Lincoln Avenue.

[1] Admitted on probation, entrance record incomplete.
[2] Special freshman.

Howes, Stanley Edward[1]	Brimfield	4 Nutting Avenue.
Huke, Barbara Allen	South Hadley	Abigail Adams House.
Hutchins, Maurice Cressey	Auburndale	Theta Chi.
Hyde, Alvin Manning	East Brimfield	35 East Pleasant Street.
Jack, Ronald Augustus	Amherst	16 Hallock Street.
Jameson, Matthew	Everett	27 Fearing Street.
Jensen, Harold Stery	Westfield	15 Phillips Street.
Johnson, Philip Gordon	Amherst	West Street.
Jones, Alvah Wesley	Salisbury	70 Lincoln Avenue.
Jones, Lawrence Lakin	Brockton	18 Nutting Avenue.
Kafafian, Sarkis Petros[1]	Kars, Armenia	11 North College.
Kelso, George	Reading	7 Phillips Street.
Lambert, John Ford	Gleasondale	9 Phillips Street.
Lane, Arthur Amidon	North Brookfield	12 Chestnut Street.
Langenbacher, Robert Frederick	New Rochelle, N. Y.	Kappa Sigma.
Langshaw, Hatton, Jr.	Fairhaven	6 Nutting Avenue.
Leedes, Joseph	Worcester	13 South College.
Lindskog, Herbert Alf	Roxbury	10 South College.
Lord, Roger Alexander	Methuen	Alpha Sigma Phi.
MacKay, Alfred Stewart	South Deerfield	44 McClellan Street.
MacMasters, Majel Margaret	Ashburnham	Abigail Adams House.
Mann, Albert Irving	Dalton	9 Phillips Street.
McCabe, Edith Mary	Holyoke	Abigail Adams House.
McGlenen, Edward Webster, Jr.[1]	Dorchester	84 Pleasant Street.
McNamara, Charles Henry	Stoughton	53 Lincoln Avenue.
Miller, Paul	Springfield	75 Pleasant Street.
Moberg, Herbert Elof	Campello	18 Nutting Avenue.
Moran, John	Amherst	61 Amity Street.
Moriarty, John Edward	Ware	7 Phillips Street.
Murphy, Edward Thomas	Hyannis	6 Nutting Avenue.
Needham, Basil Arthur	Taunton	Sigma Phi Epsilon.
Nickerson, Elsie Elizabeth	East Boston	Abigail Adams House.
Nichols, Chester Willard	Natick	32 North Prospect Street.
Norcross, Roy Ellis	Brimfield	4 Nutting Avenue.
Novick, Leo Altschuler	Amherst	56 Pleasant Street.
Noyes, Eliza Margaret	Greenfield	Abigail Adams House.
Nylen, John Herbert	East Boston	Kappa Sigma.
Otto, Raymond Herman	Lawrence	29 Lincoln Avenue.
Palmer, Cary Davis	Grafton, Vt.	31 East Pleasant Street.
Parsons, Sidney Wing	Conway	83 Pleasant Street.
Peckham, Carlisle Houghton	Melrose Highlands	6 Nutting Avenue.
Perry, George Nelson	Waltham	15 South College.
Pomeroy, Elisabeth Clark	Longmeadow	Abigail Adams House.
Potter, Royal Wesley	Providence, R. I.	3 McClure Street.
Pray, Frederick Carrol	Cambridge	1 North College.
Putnam, Ruth Evelyn	Greenfield	Abigail Adams House.
Reed, Charles Porter	West Bridgewater	18 Nutting Avenue.
Richards, James Marsh	Springfield	10 North College.
Richardson, Henry Howe	Millis	31 East Pleasant Street.
Rivnay, Ezekiel[1]	Holyoke	17 Pleasant Street.
Roberts, Verne Edward[1]	Worcester	Amherst Tavern.
Rogers, John	Cambridge	27 Fearing Street.
Rogers, Oscar Bailey	Hampden	52 Pleasant Street.
Rowen, Edward Joseph	Westfield	31 East Pleasant Street.
Sargent, Carmeta Elizabeth	Shrewsbury	Abigail Adams House.
Sawyer, Roland Damon, Jr.	Ware	18 Nutting Avenue.
Shea, Margaret Catherine	Holyoke	Abigail Adams House.
Shedd, Wendell Phillips	Arlington	10 North College.
Simonds, Henry Erving	Winchester	9 Phillips Street.
Smiley, Ray Guild	Worcester	Alpha Sigma Phi.
Smith, Albert Charles	Springfield	8 North College.
Smith, Margaret Park	Taunton	Abigail Adams House.
Smith, Raymond Ellingwood	Manchester	20 Lessey Street.

[1] Admitted on probation, entrance record incomplete.

Sniffen, Fillow Loren	Westport, Conn.	84 Pleasant Street.
Snyder, Allan	Holyoke	12 North College.
Spooner, Raymond Hildreth	Brimfield	22 North Prospect Street.
Staniford, Duncan Mooar	Reading	15 Fearing Street.
Stevens, Alvin Gay	Needham	3 Nutting Avenue.
Stopford, William Turner	Newtonville	15 South College.
Stowell, Walter Henry	Grafton, Vt.	31 East Pleasant Street.
Sturtevant, George Stanley	Ware	North College.
Sullivan, Charles Noyes	Fall River	3 Nutting Avenue.
Sullivan, Donald Clifford	Amherst	25 Gray Street.
Sullivan, Edward Francis	Warren	5 North College.
Sweetland, Augustus Francis	Stoneham	83 Pleasant Street.
Temple, John Burrington	Shelburne Falls	53 Lincoln Avenue.
Thompson, Gerald Thayer	Shelburne Falls	6 Nutting Avenue.
Thurlow, George Harold	West Newbury	70 Lincoln Avenue.
Tripp, Kenneth Bliss	Spencer	4 North College.
Tucker, Edwin Locke	Baldwinsville	75 Pleasant Street.
Tulenko, John	Sunderland	Sunderland.
Turner, Charles Edgar	Springfield	Care of Mr. Green, Mount Pleasant.
Vaughan, Elliott Stephens[1]	Pelham	Pelham.
Wade, Windsor Burt	Andover	70 Lincoln Avenue.
Wagnet, William Reinhold	Sunderland	Care of Mrs. Geo. Cooley, Sunderland.
Waite, Clifton Brooks	Orange	53 Lincoln Avenue.
Walsh, Phillip Baker	Amherst	35 East Pleasant Street.
Warren, Francis Walter	Stow	Farmhouse.
Wheeler, Ellsworth Haines	Bolton	Care of Mr. Everson.
White, Montague	West Hartford, Conn.	17 Fearing Street.
Whithed, Francis Marshall	Bernardston	7 Nutting Avenue.
Williams, Donald Reed	Northfield	116 Pleasant Street.
Williams, James Rufus	Glastonbury, Conn.	83 Pleasant Street.
Worssam, Horace Herbert	Deerfield	59 Sunset Avenue.
Zinn, Arnold Stanhope	New York, N. Y.	81 Pleasant Street.

Special Students.

Brennan, Joseph Edward	Woonsocket, R. I.	8 Allen Street.
Chapman, Lena	Amherst	77 South Pleasant Street.
Clevenger, Leander Stanley	Westmont, N. J.	21 Fearing Street.
Coveney, John Joseph	Amherst	North Amherst.
Delaney, Rose Margaret	Holyoke	Draper Hall
Hescock, Robert Eddy	Amherst	31 East Pleasant Street.
Loring, Frank Sumner, Jr.	Gloucester	35 North Prospect Street.
Mercier, Marie	Northampton	Draper Hall.
Miller, Johnetta Isabel	North Adams	Abigail Adams House.
Smith, Myron Newton	Worcester	13 North College.
Stillwell, Albert Clifton	Brooklyn, N. Y.	25 Pleasant Street.
Takevchi, Denchi	Springfield	21 Fearing Street.
Viets, Paul Winthrop	Amherst	5 Kendrick Place.

Registered after the Catalogue for 1921 was published.

1925.

Aiken, Howard William	Holyoke.

Specials.

Davidson, Clarence Herbert	Amherst.
Thayer, Charles Hiram	Amherst.

[1] Admitted on probation, entrance record incomplete.

Geographical Summary.

Massachusetts	461
New York	12
Connecticut	11
Maine	7
New Jersey	7
Rhode Island	6
Vermont	5
New Hampshire	4
Ohio	4
Florida	2
Indiana	2
Minnesota	2
Missouri	2
District of Columbia	1
Illinois	1
Maryland	1
North Carolina	1
Canada	3
Cuba	1
China	2
Armenia	1
Asia Minor	1
Total	537

Summary by Classes.

Class.	Men.	Women.	Total.
Graduate school	48	6	54
Class of 1923	84	7	91
Class of 1924	89	6	95
Class of 1925	91	6	97
Class of 1926	167	20	187
Specials	9	4	13
Totals	488	49	537

SHORT COURSE ENROLLMENT.

Two-year Graduates, 1922.

Adair, Eldred	Roslindale.
Adams, John	Cambridge.
Axtman, John Louis	Chestnut Hill.
Barney, Ernest Wellman	Corinna, Me.
Bartholomew, Francis Michael	Amherst.
Belcher, Edgar Estes	East Weymouth.
Betterley, Guy William	Brattleboro, Vt.
Bosworth, Earl Kenneth	Orange.
Breen, Arthur Joseph	Granby.
Brown, Milton Shumway	Templeton.
Campbell, Lewis Harold	Leominster.
Chamberlain, Bert Neverson	Hudson.
Clifford, Lura Marion	Greenfield.
Cluff, Victor Newton	Lowell.
Coles, Howard Finlay	Tarrytown, N. Y.
Condon, Thomas Casey	Medford.
Considine, Francis Anthony	Watertown.
Cushman, John Kenneth	Springfield.
David, James Vernon	Amherst.
DeLano, Wilbert Kilbourne	New York, N. Y.
Diebner, Louis Theodore, Jr.	Gloucester.
Donnellan, Arthur Lindsley	Cobalt, Conn.
Dunbar, Albert Jarvis	Greenwood, R. I.
Erickson, Karl Henrick	Somerville.
Etzel, George Frank	Amherst.
Fisher, William Smith	North Attleborough.
Flagg, Nolan Randolph	Worcester.
Gavett, George Billings	South Portland, Me.
Gifford, Franklin Maynard	Middleborough.
Gokey, Emery	Rutland, Vt.
Green, George Alexander	Cambridge.
Gustafson, Gustaf Albert	Sweden.
Hagan, Patrick	Ireland.
Harrison, Nicholas Peter	England.
Harrington, William John	Rutland, Vt.
Haskins, Gerald Everard	Easthampton.
Headberg, A. Edward	Somerville.
Heald, Edwin Tracy	Ashburnham.
Hibbard, Perley	Dedham.
Humphrey, Lawrence Edmund	Wareham.
Hurd, Merton Bartlett	Spencer.
Igo, Bernard James	Somerville.
Jacomb, Constance Lucy	Groton.
Jaeckle, Matthew Lawrence	Nantucket.
Johnson, Carl Eugene	Gloucester.
Keirstead, Ralph Ramsay	Worcester.
Keith, George Robert	Worcester.
Kesseli, Howard Maxwell	Worcester.
Knightly, George Thomas	Amherst.
Knowles, Frank	Dorchester.

Kohlrausch, George Edwin	Chelsea.
Leavitt, Dorothy Wilmer	Whitman.
Markham, Albert Gallitin, Jr.	Springfield.
MacKnight, Harry Murchie	Orange.
Nettleton, Francis Irving	Shelton, Conn.
Norrington, Henry	Neponset.
Norton, Frances Close	Salisbury, Conn.
Packard, Marjory Emma	Ashfield.
Parsons, Howard Joel	Conway.
Paquett, Arthur Leon	Malden.
Powell, Katharine Leslie	Newton Center.
Ramsdell, Kenneth Hammond	Southville.
Rhodes, Charles Ernest	Amherst.
Rhodes, Paul Griggs	Lynn.
Ripley, David Hamilton	Blandford.
Ritchie, Harry Ellsworth	Rutland, Vt.
Robinson, George Sutherland	Lynn.
Robinson, Leo Victor	Athol.
Ross, Ian Hamilton	New York, N. Y.
Sanford, Paul Reed	North Adams.
Sawyer, John Henry	North Brookfield.
Sherwood, Joseph Morgan	Huntington.
Slate, Herbert Taylor	Bernardston.
Smith, Willard Stevenson	Holden.
Standley, Wallace	Cambridge.
Sullivan, Joseph Stephen	Holyoke.
Thouin, Faina Gladys	Easthampton.
Wadman, Loran Wood	Medford.
Warner, Harry Freeman	Wollaston.
Whitcomb, Harold Adams	Concord Junction.
White, Donald Mitchell	Brooklyn, N. Y.
Wilson, Frank Edward	Warren.
Wilson, Harold Elton	Barre, Vt.
Woodworth, Ralph Merrill	Rowley.
Worthley, James Everett	Greenwood.

Vocational Poultry Graduates.

December, 1921.

Bobb, Lynn	Blandford.
Coupard, Louis	Lexington.
Gaudette, Claude	Somerville.
Igo, Bernard James	Somerville.
MacMillan, Murray	Medford.
McKenna, Philip	Hyde Park.
Moore, Lloyd	Worcester.
Morse, Herbert Edgar	Foxborough.
Talbot, William	Quincy.
Wilson, Harvey	Boston.

June, 1922.

Bardwell, George Arthur	Boston.
Beyea, Elmer Roland	Wakefield.
Convery, Edward Francis	Amherst.
Daisy, Walter Edward	Roslindale.
Earl, John Joseph	Amherst.
Graumann, Lewis Matthew	Roxbury.
Rodwaye, George Wildemere	Amherst.
Stillwell, Albert	Brooklyn, N. Y.
Walsh, Paul Bernard	Worcester.
Walsh, William Harold	Jamaica Plain.
Warner, Harry	Boston.

Two-year Course, 1922-23.

SECOND YEAR.

Adams, Alton Wales	Brattleboro, Vt.	36 North Prospect Street.
Albee, Frank Smith	Lee	15 Hallock Street.
Allen, Milton Clifford	North Dartmouth	Kolony Klub.
Ambrose, Earle Clifford	Amherst	6 Phillips Street.
Armstrong, John Shepard	Attleboro	23 East Pleasant Street.
Austin, Eunice Marie	Fall River	Abigail Adams House.
Bacon, Harold Northrup	Welfare Island, N. Y.	Kolony Klub.
Bangs, Walter Albert	Somerville	10 McClellan Street.
Barnicle, Edward Joseph	Waltham	17 Kellogg Avenue.
Barrett, Avery Herbert	Brattleboro, Vt.	36 North Prospect Street.
Beekman, Warren Amerman	Clover Hill, N. J.	15 Hallock Street.
Beley, Robert Arsene	Newtonville	36 North Prospect Street.
Benson, John Melvell	Mount Desert, Me.	44 Pleasant Street.
Blake, Roger Clarence	East Bridgewater	Middle Street.
Bligh, Norman Francis	West Willington, Conn.	29 East Pleasant Street.
Booth, Sarah Elizabeth	Springfield	Abigail Adams House.
Breivogel, Henry Adam	Amherst	13 Amity Street.
Brown, Herbert Ellsworth	Holden	Pine Street.
Burrington, Frederick William	Heath	15 Hallock Street.
Carlson, Carl Albert	Beverly	3 McClellan Street.
Caron, Albert Francis	Orleans, Vt.	16 Nutting Avenue.
Carroll, Charles Raymond	Amherst	24 South East Street.
Carver, Richard Constance	Dwight	Dwight, Box 44.
Case, Richard Scofield	Winchester	73 Pleasant Street.
Chisholm, Roy Bedford	Dorchester	27 Fearing Street.
Cox, Henry Jarus	Melrose	Care of W. H. Howes, North Amherst.
Crandall, Alfred Arthur	Montpelier, Vt.	73 Pleasant Street.
Cutler, Walter Leon	Springfield, Vt.	Kolony Klub.
Daw, Elwyn Hudson	Amherst	8 Kellogg Avenue.
DeNyse, Arthur William	North Amherst	North Amherst.
Diebner, Louis Theodore	Amherst	8 North Prospect Street.
Edminster, Allen W.	Brooklyn, N.Y.	Care of F. C. Kenney, Mount Pleasant.
Elliott, William James, Jr.	Brookline	15 Hallock Street.
Emerson, Theodore Waldo	Chelmsford	13 Phillips Street.
Fairman, Frederick Donald	Amherst	Amherst, R. F. D. No. 1.
Feeney, Charles Joseph	North Amherst	North Amherst.
Foster, Henry Cope	Centerville, R. I.	20 Lessey Street.
Gallison, Winfield Hancock	Amherst	Cowles Lane.
Gammon, Walter Elmer	Whitinsville	20 Spring Street.
Grayson, Donald Dean	South Milford	Hatfield.
Harvey, William Moody	Waltham	17 Kellogg Avenue.
Hastings, Edward Henry	Worcester	Kolony Klub.
Haugland, John Richard	Somerville	3 McClellan Street.
Hayward, Lester Burton	Amherst	West Street.
Hazard, James Joseph	Providence, R. I.	18 Spring Street.
Healey, Martin Joseph	Amherst	11 Salem Street.
Henry, Carl Blaney	Westborough	45 Pleasant Street.
Hersome, Clyde Elwood	Lowell	Baker's Place.
Hesse, Fred August	Hasbrouck Heights, N. J.	20 Lessey Street.
Hesse, Louis August	Hasbrouck Heights, N. J.	20 Lessey Street.
Johnson, Harold Webster	Melrose Highlands	15 Fearing Street.
Jones, Lindsey Luther	Amherst	R. F. D. No. 2.
Kavanaugh, John Fordey	Amherst	Pelham Road.
Kelley, Edward Bernard	South Hadley Falls	44 McClellan Street.
Kelly, S. Schofield	Blackstone	17 Kellogg Avenue.
Kenison, Ralph Milton	Saugus	37 Cottage Street.
Kitchell, Wilfred Harold	Winthrop	40 Amity Street.
Kleyla, Beatrice Barbara	South Deerfield	Abigail Adams House.

Kruk, John Alexander	South Deerfield	South Deerfield.
Kuppers, John Leonard	Worcester	20 Lessey Place.
Legare, Roy Roosevelt	Petersham	South Amherst.
Legro, Chester James	Lynn	27 Fearing Street.
Leitch, Fredonna	Amherst	9 College Avenue.
LeMoult, Everett Joseph	New York, N. Y.	75 Pleasant Street.
Luther, Bradford Wheeler	Fairhaven	18 Spring Street.
Marshall, Frederick William	Altona, N. Y.	9 High Street.
Mattimore, James Francis	Worcester	10 Kellogg Avenue.
McKinstry, John Percy	Southbridge	94 Pleasant Street.
McNamara, Francis Joseph	Boston	116 Pleasant Street.
Merrifield, Ralph Addison	Athol	North Amherst.
O'Donnell, Joseph Charles	East Boston	21 Pleasant Street.
Outhuse, Donald Stedman	Littleton	84 Pleasant Street.
Packard, Edward Albert	Dorchester	116 Pleasant Street.
Park, William Hamlin	Newtonville	9 Fearing Street.
Peirce, Elisha Nye	Waltham	35 East Pleasant Street.
Perry, Udell Thurston	Santuit	44 Pleasant Street.
Phinney, Henry	West Roxbury	18 Spring Street.
Potter, Raymond Terry	Great Barrington	83 Pleasant Street.
Rambo, Samuel Everett	Grafton	Sunderland.
Rand, Arden Wilfred	Amherst	12 Beston Street.
Rand, George Lester	North Weymouth	18 Nutting Avenue.
Ravinski, Albert John	Dover	Leverett Road.
Rawson, Floyd Stuart	East Douglas	24 Lessey Street.
Richardson, Milton C.	West Brookfield	84 Pleasant Street.
Sahlin, Harry Sixten	Dorchester	20 Lessey Street.
Sayles, Arthur Updike	Providence, R. I.	Baker Place.
Schnitzer, Harold Edward	Newport, R. I.	36 North Prospect Street.
Scribner, Harry Verne	Waltham	Sunderland.
Shepherd, Owen	Bronxville, N. Y.	81 Pleasant Street.
Slattery, John Thomas	Hatfield	32 High Street.
Smith, Charles Emerson	Westfield, N. J.	75 Pleasant Street.
Smith, William	Whitinsville	35 North Prospect Street.
Spengler, Robert	Springfield	3 Nutting Avenue.
Spooner, Edward Howland	Brimfield	22 North Prospect Street.
Springer, Harry Brooke	Amherst	North Amherst.
Stever, Clifton Baird	Yarmouth Port	23 East Pleasant Street.
Stickney, Burton Marsh	Chester, Vt.	Kolony Klub.
Sullivan, Frank Leo	North Andover	35 North Prospect Street.
Sullivan, John Michael	Cambridge	36 North Prospect Street.
Sunbury, Kenneth Arthur	Lowell	Colonial Inn.
Swanson, Paul Fredolf	Chelmsford	42 McClellan Street.
Swenbeck, Herman Robert	Boston	116 Pleasant Street.
Taft, George Kenneth	Mendon	Colonial Inn.
Thomas, Leon Chessman	South Weymouth	18 Nutting Avenue.
Trull, Benjamin Franklin	Lowell	84 Pleasant Street.
Tufts, William Harold	North Easton	North Amherst.
Walker, Wallace Hayward	Ashby	Stockbridge Hall.
Wales, Forrest Martin	Stoughton	70 Lincoln Avenue.
Ward, Nelson Erwin	Buckland	94 Pleasant Street.
Watson, Grant Mack	Amherst	R. F. D. No. 3, Box 72.
Weagle, Dennis William Scot	Marlborough	75 Pleasant Street.
Webster, Phyllis M.	Cambridge	Abigail Adams House.
Weed, Theodore Henry	Lenox	9 Fearing Street.
Wells, Alphonsus	Brighton	Colonial Inn.
Wentworth, Wesley John	Amherst	R. F. D. No. 1.
Westervelt, Harold Eric	Tenafly, N. J.	23 East Pleasant Street.
Wheeler, Charles Paine	Brimfield	Kolony Klub.
Wiedenmayer, George B.	Glen Ridge, N. J.	Sunset Avenue.
Wilson, Henry James	Boston	Apiary.
Woodward, Everett Brigham	Hubbardston	Experiment Station Barn.
Wydeen, Albert Ferdinand	Amherst	R. F. D. No. 1.

FIRST YEAR.

Adelt, Joseph Francis	Adams	Baker Place.
Aiken, Howard William	South Hadley	22 Amity Street.
Alander, John Alfred	Kingston	30 North Prospect Street.
Aldrich, James Arin	Belchertown	17 Phillips Street.
Baker, Herbert Kingsbury	Wellesley	20 Lessey Street.
Baker, Ralph Holabird	Cambridge	7 McClellan Street.
Billings, Samuel Thurston	Ashland	Colonial Inn.
Bisbee, John Carroll, Jr.	Moretown, Vt.	35 East Pleasant Street.
Blanchard, Lawrence Newell	Leominster	Care of Professor Sears.
Blue, James Reuben	Stone Point, Va.	35 East Pleasant Street.
Booth, George Wellesley	Everett	29 East Pleasant Street.
Bowden, Leon Melvin	West Roxbury	Meadow Street.
Brewster, Malcolm Leslie	Waltham	8 South Prospect Street.
Briggs, Arthur Clenton	Falmouth	Colonial Inn.
Bryant, Berton Davis	Lowell	101 Pleasant Street
Caless, Thomas Winfred	Belmont	Amherst Tavern
Carageorgis, Andrew Stefanon	New Bedford	Apiary.
Carter, William Bradley	Tewksbury	101 Pleasant Street.
Cassidy, Francis P.	Plainville, Conn.	3 Nutting Avenue.
Chaisson, Joseph Daniel	Worcester	Amherst Tavern.
Clarkson, Arnold	Reading	Colonial Inn.
Clune, Arthur John	Springfield	7 McClellan Street.
Cole, Albert Bradley	Millbrook, N. Y.	29 Lincoln Avenue.
Conklin, Lester Martin	Patchogue, N. Y.	29 Lincoln Avenue.
Coombs, Marjorie Donelson	Shelburne Falls	Abigail Adams House.
Craig, Kenneth	Boston	28 Northampton Road.
Creeron, Hugh Joseph	Worcester	36 North Prospect Street.
Cromack, Edwin Baldwin	Colrain	6 Nutting Avenue.
Cutler, Samuel Austin	Boylston	8 South Prospect Street.
Darling, Walter	Franklin	12 South Prospect Street.
Dawson, Robert Entwistle	Saxonville	17 Phillips Street.
Dennen, Charles Otis	East Pepperell	31 North Prospect St.
Dennison, Leon Henry	Atlantic	83 Pleasant Street.
Densmore, Theodore Calder	Natick	Colonial Inn.
Eastwood, Wilfred	North Adams	79 King Street, Northampton.
Eaton, Wallace Freeman	Springfield	Amherst Tavern.
Emery, Edward Conant	Weymouth Heights	Care of Geo. Cooley, Sunderland.
Emery, Russell Louis	Needham	35 East Pleasant Street.
English, Sherman Clements	Mattapan	101 Pleasant Street.
Falconer, Robert Norris	Hyde Park	17 Kellogg Avenue.
Field, Brierly	Scarsdale, N. Y.	6 Phillips Street.
Files, Arthur Dysart	Wilbraham	30 North Prospect Street.
Finney, John Taft	Brookfield	17 Kellogg Avenue.
Fitts, Harry Bucklin	Orange	36 North Prospect Street.
Fortune, Battie Holmes	Boston	Abigail Adams House.
Freeman, Hayden	Winthrop	7 Nutting Avenue.
Garrett, Wallace Frederick	Milton	Colonial Inn.
Gates, Mary Ellen	Amherst	50 Amity Street.
Gibbs, Karl Everett	Cochituate	75 Pleasant Street.
Giessler, Carl Donald	New York, N. Y.	81 Pleasant Street.
Glencross, John Donald	Amherst	15 Hallock Street.
Goode, Frank Arthur	Boston	Colonial Inn.
Goodnow, Alice Marguerite	Athol	Abigail Adams House.
Griffith, Harold Winthrop	Amherst	18 Nutting Avenue.
Haffermehl, Forrest Wendell	Newton Center	Colonial Inn.
Harris, George Mitchell	Lynn	8 South Prospect Street.
Haskell, Dorothy Edith	Holyoke	Abigail Adams House.
Haynes, Joseph Dwight	Keene, N. H.	Care of Professor Banta, Sunset Avenue.
Hazen, Stanley Luther	Longmeadow	Pine Street.

Hermance, Warren Edwin	Boston	North College.
Higgins, Leonard Martin	Fall River	3 Nutting Avenue.
Hillman, Nelson Bennett	Fairhaven	15 Hallock Street.
Hoar, Richard Edwin	Winchendon	30 North Prospect Street.
Howe, Wesley Mason	Millbury	6 North College.
Hulbert, Jewett William	Dorchester	30 North Prospect Street.
Hull, Amy Harriet	Agawam	Abigail Adams House.
Huntley, Ernest John, Jr.	Springfield	28 Amity Street.
Jackson, John Windfield, Jr.	Belchertown	17 Phillips Street.
Jennings, Thomas Joseph	New Bedford	7 McClellan Street.
Johnstone, Allerton	Hamilton	83 Pleasant Street.
Jones, Charles K.	Waitsfield, Vt.	18 Nutting Avenue.
Jones, Wendell Albert	Roslindale	7 McClellan Street.
Joslin, Ralph Herbert	Waitsfield, Vt.	35 East Pleasant Street.
Kelley, Malachi Mitchiel	Northbridge	Amherst Tavern.
Kenney, William Francis	Dorchester	35 East Pleasant Street.
Kinder, Lawrence Philip	Framingham	17 Phillips Street.
Kozanis, George Nicholas	New Bedford	Apiary.
Lacombe, Albert George	Beverly	12 South Prospect Street.
Lalumiere, William	Haverhill	15 Fearing Street.
Lane, Maynard Wallace	Gloucester	23 East Pleasant Street.
Lauterbach, Louis Jacob	Roslindale	5 Spring Street.
Longley, Lawrence Stanley	Greene, Me.	29 North Prospect Street.
Lowe, Dwight Mansfield	Watertown	8 Allen Street.
MacFadyen, Alfred Wellington	Wellesley	20 Lessey Street.
MacLeod, Everett William	Reading	Colonial Inn.
Macuen, Harvey Andrew	Newton	8 Kellogg Avenue.
Malouf, Elias S.	Boston	Amherst Tavern.
Martin, Emilio Elenterie	Buenos Aires, Argentina	3 McClellan Street.
Martyn, Roland Fowler	West Suffield, Conn.	3 Nutting Avenue.
Maxson, Willis Henry	Berkeley, Cal.	28 Northampton Road.
McGrath, Matthew	Dedham	17 Phillips Street.
Merchant, Percy Albert	Gloucester	23 East Pleasant Street.
Miller, Everett Woodman	Fairhaven	15 Hallock Street.
Morrissey, John Francis	Brooklyn, N. Y.	Amherst Tavern.
Murphy, Mortimer Vincent	Norwood	66 Pleasant Street.
Norell, John	Sunderland	Sunderland.
O'Connor, Harold Francis	Weymouth	101 Pleasant Street.
O'Connor, Joseph Francis	Lynn	Amherst Tavern.
O'Doherty, John Edward	Woburn	Amherst Tavern.
O'Hara, Francis Edward	Worcester	36 North Prospect Street.
Olsen, Harold Bailey	Pepperell	31 North Prospect Street.
Paddock, Franklin Selby	Worcester	Farmhouse.
Palmer, Albert Tresnon	Everett	13 South Prospect Street.
Patterson, Millard James	Ipswich	37 Cottage Street.
Paûlson, Rudolph Bror	Somerville	8 South Prospect Street.
Peaslee, George Raymond	Pittsfield	20 Lessey Street.
Peck, John Wesley	Seekonk	116 Pleasant Street.
Pekleris, Spiros Antony	Lowell	Meadow Street.
Prentiss, Arthur Palmer	Danvers	22 Sunset Avenue.
Price, Clifford Abel	Medford	29 North Prospect Street.
Rambo, Mildred Evelyn	Sunderland	Sunderland.
Ramsbottom, Thomas	Lowell	15 Phillips Street.
Ray, Gordon Horace	West Newbury	12 South College.
Rodeen, William	Ludlow	69 Main Street.
Rooks, Roger Franklin	Somerville	3 McClellan Street.
Sahlin, Carl Evert	Somerville	31 East Pleasant Street.
Sargent, Stanley Morse	Amherst	6 Nutting Avenue.
Scotland, Gordon Lionel	Saxonville	17 Phillips Street.
Scribner, Esther Helen	Sunderland	Sunderland.
Smith, Harold Earle	Springfield	17 Phillips Street.
Smith, William John	Charlestown	Amherst Tavern.
Solomon, Maurice	Melrose	56 Pleasant Street.
Sprague, Gordon Charles	Boston	The Davenport.

Stevens, Glenn William	Waverley	61 Amity Street.
Stover, Walter Edward	Wellesley Hills	20 Lessey Street.
Taylor, Henry Pease	Westfield	83 Pleasant Street.
Tobin, Michael Francis	Adams	28 Amity Street.
Thompson, George Howard	Worcester	One Acre.
Tirrell, Philip	Quincy	7 McClellan Street.
Tucker, Clarence Murray	Waitsfield, Vt.	35 East Pleasant Street.
Turffs, Clarence Joseph	Worcester	Kolony Klub.
Walker, Franklin Perry	Westborough	3 Nutting Avenue.
Wentworth, Frederick Henry	Jamaica Plain	Colonial Inn.
White, Laurence Schaffner	Dover	31 North Prospect Street.
White, Newell Dudley	Bristol, Conn.	Pelham Road.
Young, Francis Arthur	Northampton	121 Florida Avenue, Northampton.

Vocational Poultry Course, 1922–23.

Binner, Lawrence Howard	Amherst	29 Northampton Road.
Cannon, Timothy Francis	Roxbury	15 Fearing Street.
Knight, Henry Elbridge	Amherst	71 Main Street.
Lowd, Henry Lewis	Amherst	15 Spring Street.
Mailloux, Conrad	Woonsocket, R. I.	75 Pleasant Street.
O'Brien, James Laurence	Dorchester	6 Phillips Street.
Putnam, Ethel Davis	Worcester	Abigail Adams House.
Shulver, Arthur	Amherst	North Amherst.
Thibault, Arthur Joseph	Lowell	116 Pleasant Street.

Winter School, 1922.

Applegate, Russell	Rhinebeck, N. Y.
Bailer, John J.	New York, N. Y.
Balch, Merrill L.	Manchester, Conn.
Barnes, Leon D.	Southwick.
Barnes, Marion D.	Southwick.
Barney, Laurence H., Jr.	New Bedford.
Bartley, Francis J.	Falmouth.
Beckley, Park A.	Harrisburg, Pa.
Beem, Guy O.	Los Angeles, Cal.
Benson, Doris	North Carver.
Berg, Henry	Chelmsford.
Beveridge, Henry L., Jr.	Indianapolis, Ind.
Bins, Rudolph	Guilderland, N. Y.
Boman, Lauri	Ashburnham.
Bray, Russell S.	Framingham.
Brickman, Anna L.	Great Barrington.
Brown, Frederick Davis	Webster.
Buczala, Stefan	Northampton.
Carter, Frederick M.	Tewksbury.
Cobb, Robert	Newton Highlands.
Cummings, Edwin P.	Danvers.
Dickinson, Charles A.	North Amherst.
Diehl, Mary E.	Marwin, Pa.
Edlmann, Violet F.	Albany, N. Y.
Falconer, Robert N.	Hyde Park.
Felton, Nellie K.	Amherst.
Feronetti, James	Bedford.
Fiske, Helen S.	Fairhaven.
Fortescue, Crawford E.	Wellesley Farms.
Garfield, Henry G.	Saxonville.
Garmon, Roland E.	Lexington.
Gates, Lucinda	Allston.
Gavett, Mary M.	Amherst.
Gay, Albert D.	Greenfield.
Glover, Benjamin F.	Roslindale.
Goldthwaite, Willard J.	Dunstable.

Goller, Joseph L.	West Hatfield.
Goodwin, Charles G.	Springvale.
Goold, George G.	Sussex, N. B.
Grove, Gilbert P.	Milton.
Haigh, Alfred J.	Newton Upper Falls.
Hall, Everett L.	Dover.
Hamilton, Ralph E.	Rowe.
Hamilton, Sarah C.	Newton Center.
Hansen, Charles E.	North Granby, Conn.
Harris, Homer B.	Middlebury, Vt.
Hemphill, James A.	Westerly, R. I.
Heurlin, Victor H.	South Braintree.
Hill, Arthur	Littleton, N. H.
Hilton, Guy W.	Marblehead.
Howarth, Marion L.	Scranton, Pa.
Howe, James S.	Brookline.
Jaques, Paul	Randolph.
Jonasson, Victoria M.	Gloucester.
Josselyn, David A.	Weymouth Heights.
Kendall, Edward D.	Holden.
Kerachsky, Harry L.	Leonard Bridge, Conn.
Larsen, Anna C.	East Northfield.
Lauterbach, Louis J.	Roslindale.
Law, David U.	Lynnfield.
MacColbert, Murry	Northampton.
McElligott, Bernard	Westfield.
McElligott, Francis	Westfield.
Mitchell, Donald	Billerica.
Mullen, George P.	Bridgeport, Conn.
Norton, Margaret Sedgwick	Salisbury, Conn.
Olds, Elmer O.	North Chester.
Patriquin, Harvey	Rockport.
Pomfrey, Gordon S.	Marlboro, Vt.
Putnam, Howard A.	Springfield.
Rambo, Mildred E.	Amherst.
Reed, MacMinn N.	East Brewster.
Rice, Ellen C.	Lancaster.
Rogers, George W	Brooklyn, N. Y.
Ruud, Alfred	Newtonville.
Scott, Everett W.	Pepperell.
Scribner, Esther H.	Waltham.
Slack, Howard E.	Brookline.
Smiddy, Earl R.	Fayville.
Smith, Nathan	Waltham.
Solomon, Hyman S.	Colchester, Conn.
Somes, Ronald K.	North Edgecomb, Me.
Stacy, Charles F.	Pepperell.
Stranger, Walter F.	West Newbury.
Strong, Harvey G.	Amherst.
Taylor, Henry P.	Westfield.
Thompson, Eugene L.	Florence.
Thompson, Frank A.	Roxbury.
Turner, George	Newton.
Unwin, Vera E.	Amherst.
Vanderhoop, William D.	Gay Head.
Walker, Edwin H.	East Pepperell.
Watres, Mrs. Harold A.	Wellesley.
Welchans, William H.	Waltham.
Wetherbee, Royal	West Acton.
Williamson, Alton W.	Norton.
Yale, Margaret	Utica, N. Y.

Course for Country Clergymen, April 17 to 21, 1922.

Allen, George E.	Plainfield.
Anderson, William B.	Montague.
Barker, G. A.	New Salem.
Blackmer, E. F.	Belchertown.
Brown, William Channing	Boston.
Coffin, George H.	Shelburne.
Crowell, Preston R.	Stow.
Dilts, Asa R.	Amherst.
Emrich, F. E.	Boston.
Ferrin, Allan C.	Chester.
Ferrin, Mrs. A. C.	Chester.
Foxall, Thomas	Sunderland.
Godfrey, W. H.	Williamsburg.
Goodrich, L. B.	Taunton.
Hawley, John A.	Amherst.
Hilliard, D. L.	Erving.
Jacobson, Henry	Conway.
Jones, Newton I.	Worthington.
Kerr, Archibald	South Amherst.
Luther, Clair F.	Amherst.
MacArthur, Kenneth C.	Cambridge.
Miner, Dr. Harold E.	Springfield.
Oxnard, Henry E.	Rehoboth.
Peterson, H. M.	Medfield.
Plumb, Albert	Gill.
Pyke, F. M.	Goshen.
Root, E. Tallmadge	Boston.
Smith, Caleb E.	Prescott.
Smith, Charles H.	Granby.
Stevens, Charles L.	South Deerfield.
Watson, Albert P.	Hatfield.
Wightman, John C.	Northampton.
Wightman, Mrs. J. C.	Northampton.

Summer School, 1922.

Aldrin, Andrew C.	Worcester.
Allen, Ralph C.	Walpole.
Alvord, Alice W.	Easthampton.
Balboni, Eva	Bridgewater.
Barnes, Lincoln W.	Amherst.
Barnwell, Benjamin B.	Frogmore, S. C.
Barry, Anna	Erie, Pa.
Beahan, Ann L.	Boston.
Beahan, Mary T.	Boston.
Beals, Carrie B.	Hulls Cove.
Belcher, D. Webster	North Easton.
Bennett, Mabel	Amherst.
Binner, Lawrence H.	Amherst.
Binner, Theresa C.	Amherst.
Bittinger, Joseph F.	Northfield.
Bolingbroke, Isobel	Roxbury.
Booth, Sarah E.	Longmeadow.
Bowman, Marion	Amherst.
Brennan, Frances A.	Avon.
Brown, Leslie M.	Hudson.
Buchanan, Walter G.	Amherst.
Burr, Alice E.	North Cohasset.
Butterworth, Caroline E.	Amherst.
Canavan, Anna Marie	Amherst.
Carlton, Louise E.	Worcester.
Carter, Clara A.	Bradstreet.

Cauley, Mary W.	Dorchester.
Cauley, Sarah L.	Dorchester.
Chandler, Georgine A.	North Amherst.
Chapin, Marion	Holyoke.
Childs, Gertrude	Amherst.
Churchill, Edith	Amherst.
Churchill, Hildegarde E.	Amherst.
Clark, Mary H.	Amherst.
Clarke, Miriam K.	Amherst.
Cole, Anna M.	Hampton, N. H.
Collins, Dorothy F.	Concord.
Corey, Isabel	Southbridge.
Crafts, Frances	Mattapan.
Daly, Katherine M.	Holyoke.
Davenport, Aris E.	Jamaica Plain.
Davidson, Joseph J.	North Stratford, N. H.
Davis, Edna M.	North Cohasset.
Davis, Elise	Amherst.
Dean, Clara R.	Revere.
Deegan, Hylda M.	Boston.
Devine, Mary R.	Amherst.
Dowd, Josephine K.	Chicopee Falls.
Dower, Catherine I.	Easthampton.
Dower, Dorothea E.	Easthampton.
Doyle, Loretta E.	Ludlow.
Estes, Lora A.	Woonsocket, R. I.
Fairbanks, Nettie L.	South Bellingham.
Fairman, Myrtle B.	Amherst.
Fentem, Alice E.	West Chester, Pa.
Fentem, Beth	West Chester, Pa.
Fenton, Alice E.	Holyoke.
Fisher, Lawrence B.	Petersham.
Fitman, Anna G.	Worcester.
Flaherty, Vera K.	Boston.
Flanagan, Anna M.	Readville.
Foley, Helen T.	Amherst.
Foster, Clara L.	Rochester, N. Y.
Frye, Florence M.	South Hadley.
Gahan, Edith F.	Amherst.
Gallagher, Frances I.	Charlestown.
Garrison, Inez	Amherst.
Gay, Merle H.	Belchertown.
Getchell, Elsa	Amherst.
Gibbons, Mrs. J. O.	Holyoke.
Gill, Anna E.	Brooklyn, N. Y.
Glasheen, Mary E.	Holyoke.
Gorman, Anna	Holyoke.
Gorman, Jane	Dorchester.
Green, Mrs. Henry S.	Amherst.
Greene, Mrs. L. V.	Amherst.
Greenwood, Helen E.	Worcester.
Harrington, Mrs. J. C.	Boston.
Higgins, Grace E.	Worcester.
Ho, Tsen	Cambridge.
Holmes, Margaret G.	Norwich, Conn.
Honney, Margaret T.	Amherst.
Hoyt, Willis H.	Needham.
Hubbard, Mrs. G. A.	Suffield, Conn.
Hulford, Ella E.	Methuen.
Hyde, Phyllis E.	Southbridge.
James, Katherine A.	Bridgewater.
Jansen, Esther C.	Amherst.
Jenks, Mildred F.	Amherst.
Jones, Ethel M.	Boston.

Keefe, Virginia M.	Amherst.
Keenan, Mary E.	Pawtucket, R. I.
Keith, Julia M.	Amherst.
Keith, Sarah P.	Amherst.
Kennedy, Irene M.	Worcester.
Kinney, Joseph	Brooklyn, N. Y.
Kinney, Lydia I.	Brooklyn, N. Y.
Kinney, Nina I.	Brooklyn, N. Y.
Knight, Elizabeth I.	Gardner.
Knightly, Mary A.	Amherst.
Lane, Mary E.	Hampton, Va.
Lanou, Irene B.	Pittsfield.
Leavitt, Dorothy W.	Whitman.
Leduc, Marguerite C.	Northampton.
Lewis, Gwendolyn	Amherst.
Loring, William R.	Hadley.
Lynch, Grace V.	Roxbury.
Lynch, Mary A.	Holyoke.
Lyons, Emma A.	Malden.
Magill, Camilla	Amherst.
Mahoney, Anna	Easthampton.
Mahoney, Ida M.	Easthampton.
Mahoney, Margaret R.	Easthampton.
Martin, Lucille A.	Amherst.
Mathews, Etta M.	Worcester.
Maxson, Willis H.	Amherst.
Mayo, William I.	Northampton.
Meehan, Lillian A.	Worcester.
Mercier, Marie	Northampton.
Miller, Gladys B.	Taunton.
Miller, Johnetta I.	North Adams.
Miller, Mary M.	Easthampton.
Mostrom, Harold A.	South Middleborough.
Murphy, Josephine	Chicopee Falls.
McCarthy, Dorothy R.	Mattapan.
McDermott, Mary E.	Fall River.
McKernon, Alice G.	Pittsfield.
McKernon, Florence D.	Pittsfield.
McNellis, M. Frances	Cambridge.
O'Brien, Katherine M.	Dorchester.
Page, Marion D.	Amherst.
Petty, Willis T.	North Dartmouth.
Phillips, Ruth L.	Amherst.
Pushee, Mrs. G. F.	North Amherst.
Ramage, Elizabeth E.	Turners Falls.
Randall, Helen	Wakefield.
Reardon, Helen E.	Hadley.
Rile, Mary E.	Plainfield, N. J.
Rogers, Katherine	New York, N. Y.
Rosen, Lena	East Dedham.
Rowell, Homer R.	Groveland.
Salmon, Mary A.	Revere.
Salter, James	Danvers.
Sawyer, Helen	Boston.
See, Anna P.	Amherst.
Sharpe, Charles G.	Amherst.
Sharpe, Helen C.	Amherst.
Shea, Gertrude A.	Dorchester.
Smith, Edith L.	Chicopee.
Smith, Emily D.	Amherst.
Smith, Wendell F.	Waltham.
Spinney, Marion F.	North Acton.
Sullivan, Julia E.	Fall River.
Sullivan, Mary G.	Roslindale.

Thompson, Mrs. Joseph O.	Amherst.
Thompson, Lulu B.	Somerville.
Topliff, Anna E.	Easthampton.
Uschmann, May E.	Holyoke.
Vance, Ruth	Norwood.
Walker, Lillian B.	Amherst.
Ward, Frances W.	Framingham.
Ward, Helen G.	Framingham.
Waugh, Dorothy	Amherst.
Waugh, Esther	Amherst.
Whitman, Kenneth	Hancock.
Winslow, Caroline S.	Brighton.
Wight, Florence B.	Leeds.
Wilcox, Harold E.	South Milford.
Willey, Minnie C.	Amherst.
Young, Euna L.	Campello.

School of Town and Country Home Life, July 17 to 22, 1922.

Blanchard, Miss Ruth	Lowell.
Blanchard, Mrs. Bertha	Lowell.
Bowker, Mrs. C. H.	Northampton.
Brigham, Mrs. George E.	Shrewsbury.
Brigham, Mrs. Angie L.	Shrewsbury.
Burnham, Mrs. H. A.	Newtonville.
Currier, Miss Mary	Wilmington.
Currier, Mrs. Walter H.	Wilmington.
Lane, Mrs. Helen D.	Worcester.
Lawrence, Mrs. Elmer	Westborough.
Lawrence, Mrs. G. C.	Westborough.
Spear, Miss Mabel G.	North Amherst.
Miller, Mrs. Mary B.	Fitchburg.
Tibbetts, Mrs. L. H.	North Wilmington.
Vaughan, Mrs. Janet	Fitchburg.
Wenzel, Mrs. Ethel M.	Fitchburg.

Students Registered after the Catalogue for 1921 was published.

Two-year Course.

Second Year.

Hart, Adrian Putnam	Cambridge.

First Year.

Cahill, Thomas Joseph	Medfield.
Keene, Herbert Porter	North Weymouth.
Malloy, Walter John	Roxbury.
Mann, Eliot Jennings Bryan	Medford.
Maynard, Joseph Francis	Worcester.
McGarrath, Walter	Brookline.
McLaughlin, Bernard Joseph	Dorchester.
Murphy, Gerard Francis	Amherst.
Pennoyer, Hugh Raymond	West Chester, Pa.
Philbrook, Harry Robinson	Chester.
Sullivan, Daniel George	Worcester.

Unit Course.

Bennett, Herbert Thomas	Hyde Park.
Day, Fred Lord	Lynn.
Finick, John Joseph	South Hadley.
Larner, Roger James	Boston.
Rainer, Albert Joseph	Adams.
Sears, George Joseph	Needham.

Vocational Poultry Course.

Castlenovo, Edward Joseph . . . . Boston.
Loring, Frank Sumner . . . . Gloucester.

Summary of Short-course Enrollment.

	Men.	Women.	Total.
Two-year Course, second year	116	5	121
Two-year Course, first year	128	8	136
Vocational Poultry Course	8	1	9
Winter School, 1922	77	20	97
Course for Country Clergymen	31	2	33
Summer School, 1922	23	147	170
School of Rural Home Life	–	16	16
Totals	383	199	582
Counted twice	2	2	4
Totals	381	197	578

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PUBLIC DOCUMENT No. 31

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ANNUAL REPORT

OF

THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

PARTS I AND II

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PUBLICATION OF THIS DOCUMENT
APPROVED BY THE
COMMISSION ON ADMINISTRATION AND FINANCE

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PART I

REPORT OF THE DIRECTOR AND OTHER OFFICERS

PART II

DETAILED REPORT OF THE EXPERIMENT STATION

BEING PARTS III AND IV OF THE SIXTIETH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE

A RECORD OF THE FORTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION

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Massachusetts Agricultural Experiment Station.

OFFICERS AND STAFF.

COMMITTEE.

STATION STAFF.

Administration.

Sidney B. Haskell, B.Sc., *Director*.
Joseph B. Lindsey, Ph.D., *Vice-Director*.
Fred C. Kenney, *Treasurer*.
Henry S. Green, A.B., LL.D., *Librarian*.
Mrs. Lucia G. Church, *Secretary to the Director*.
Miss F. Ethel Felton, A.B., *Clerk and Editorial Assistant*.

Agricultural Economics.

Alexander E. Cance, Ph.D., *Professor*.
Miss Lorian P. Jefferson, M.A., *Assistant Research Professor*.

Agriculture.

Edwin F. Gaskill, B.Sc., *Assistant Research Professor*.
Robert L. Coffin, *Investigator*.

Agronomy.

Arthur B. Beaumont, Ph.D., *Professor*.

Animal Husbandry.

Schuyler M. Salisbury, B.Sc.Agr., *Professor*.

Botany.

A. Vincent Osmun, M.Sc., *Professor*.
Paul J. Anderson, Ph.D., *Professor*.
Orton L. Clark, B.Sc., *Assistant Professor*.
Webster S. Krout, M.A., *Assistant Research Professor*.
Miss Anna M. Wallace, M.A., *Curator*.
Miss Gladys I. Miner, Stenographer.
Alyn S. Ball, *Laboratory Assistant*.

Cranberry Station.

Henry J. Franklin, Ph.D., *Research Professor in Charge*.

Dairying.

Henry F. Judkins, B.Sc., *Professor*.

Entomology.

Henry T. Fernald, Ph.D., *Professor*.
Arthur I. Bourne, A.B., *Assistant Research Professor*.
Harlan N. Worthley, B.Sc., *Investigator*.
Miss Bridie E. O'Donnell, *Stenographer*.

Farm Management.

James A. Foord, M.Sc.Agr., *Professor*.

Horticultural Manufactures.

Walter W. Chenoweth, M.Sc., *Professor*.

Vegetable Gardening and Market-Garden Field Station.

Harold F. Tompson, B.Sc., *In Charge, Market-Garden Field Station*.

Meteorology.

John E. Ostrander, A.M., C.E., *Meteorologist*.

Microbiology.

Charles E. Marshall, Ph.D., *Professor*.
Arao Itano, Ph.D., *Assistant Professor*.

Plant and Animal Chemistry.	Joseph B. Lindsey, Ph.D., *Chemist.* Edward B. Holland, Ph.D., *Research Professor.* Fred W. Morse, M.Sc., *Research Professor.* Carlton P. Jones, M.Sc., *Assistant Research Professor.* John G. Archibald, B.Sc.Agr., *Assistant Research Professor.* Charles O. Dunbar, B.Sc., *Investigator.* Harry L. Allen, *Laboratory Assistant.* James R. Alcock, *Assistant in Animal Nutrition.* Miss Margaret C. Eppler, *Clerk.*
Pomology.	Fred C. Sears, M.Sc., *Professor.* Jacob K. Shaw, Ph.D., *Research Professor.* Arthur P. French, B.Sc., *Investigator.* Miss Ethelyn Streeter, *Stenographer.*
Poultry Husbandry.	John C. Graham, B.Sc., *Professor.* Frank A. Hays, Ph.D., *Research Professor.* Miss Ruby Sanborn, A.B., *Investigator.* Miss Doris Tower, *Stenographer.*
Rural Engineering.	Christian I. Gunness, B.Sc., *Professor.*
Veterinary Science and Animal Pathology.	G. Edward Gage, Ph.D., *Professor.* Norman J. Pyle, V.M.D., *Assistant Research Professor of Avia[n] Pathology.*

CONTROL SERVICE.

Henri D. Haskins, B.Sc., *Official Chemist, Fertilizer Control.*
Philip H. Smith, M.Sc., *Official Chemist, Feed Control.*
Lewell S. Walker, B.Sc., *Assistant Official Chemist, Fertilizer Control.*
Raymond W. Swift, B.Sc., *Analyst, Fertilizer Control.*
Frank J. Kokoski, B.Sc., *Analyst, Feed and Fertilizer Control.*
James T. Howard, *Inspector, Feed and Fertilizer Control.*
Miss Cora B. Grover, *Stenographer, Feed and Fertilizer Control.*
Oliver S. Flint, B.Sc., *Analyst, Poultry Disease Elimination.*
Miss Mildred H. Hollis, *Analyst, Poultry Disease Elimination.*
John J. Smith, B.Sc., *Collector of Blood Samples, Poultry Disease Elimination.*

REPORT OF THE DIRECTOR.

SIDNEY B. HASKELL.

REVIEW OF THE YEAR.

Additions to Station Equipment.

Through appropriation made by the legislature, the Station this past year was ble to supplement its land equipment through the purchase of the farm lying nmediately north of its present area. By the vote of the trustees of the College ıis is to be known as the "William P. Brooks Experimental Farm". It contains bout sixty acres of land, most of this being tillable and admirably adapted for ͼperimental work, particularly in the two great crops of the Connecticut Valley - onions and tobacco. It is a cause for gratification that the legislature realized ıe need, for existing facilities have been taxed to the utmost.

In addition to the above there is promise of improvement in the Station land ıuipment in one other direction, this coming about through the offer from the ustees of the will of the late Miss Cornelia Warren of some fifty acres of land in 'altham, for the uses of the College. The trustees of the College have voted to ːcept the gift and have placed this in the custody of the Experiment Station in ːpectation of moving the Market Garden Field Station from Lexington to the ɜw estate in Waltham. This area has two distinct soil types, both of them relavely uniform and typical of fairly large areas, and is in many other ways better ıited for experimental work in vegetables than is our present location. At the ıte of making this report the transfer has not yet been finally made, nor has the oject been approved by the legislature. It is to be hoped, however, that the ange may be made without difficulty.

The land equipment of the Station may now be considered as complete, save ıly for two minor projects: the first relating to the purchase of a small area to pplement the equipment of the Cranberry Station; the second of land devoted pasture experimental work. This last is important to the welfare of the dairy lustry; and as soon as land now under the control of the Station is developed r experimental purposes, the project will be formally presented.

Changes in Organization Policy.

During the year a number of changes in administrative policy have been made, of these with the objective of securing greater economy. Through arrangeınts with the treasurer's office, much of the labor of accounting is now removed ɔm the Station office. The mailing lists of Extension Service and Station are now mbined, with the work done by the former organization. This is a distinct p in advance, prevents duplication of effort, and through centralization insures ver cost of handling the Station publications. In the publication work itself ɜ size of editions has been greatly reduced, and bulletins are now sent out to t restricted mailing lists or on request only. This eliminates waste circulation d insures, so far as may be possible, maximum returns from publication funds ailable. Finally, for much of the miscellaneous analytical work formerly done, charge is now being made for that part which is primarily personal service. spite the fact that the practice of making free analyses of agricultural products ı custom of long standing, this change has been put into effect with an astonish-

ingly small amount of criticism. The soundness of the Station position, that i funds must be expended for the benefit of the people in general rather than f the individual, seems to be generally accepted.

Changes in Staff.

Dr. H. D. Goodale, for nearly ten years in the service of the Departmen Poultry Husbandry, resigned June 30, 1922, on account of ill health. Dr. Gooda came to the Station from the Carnegie Laboratory, Cold Spring Harbor, Ne York, and brought to the Department of Poultry Husbandry the service of a ma trained primarily in biology and genetics. Despite the most discouraging co ditions which have attended his work, particularly the inability to control dieas on account of deficiencies in land equipment and inability to maintain quarantin Dr. Goodale made consistent and continuous progress in his breeding work. the time of his leaving the Station, he had developed a flock of Rhode Island Re from which broodiness had been largely eliminated, which was early maturin which laid heavily in winter, and which finally had given an average of 200 eg per bird as the annual production. It was with very great regret that Dr. Goodal resignation was accepted.

The position of Research Professor of Poultry Husbandry has been filled the appointment of Dr. Frank A. Hays, who entered on his duties September 2 1922. Dr. Hays comes to the institution after service in Delaware, Iowa a Wyoming. He has already had a large amount of experience in research wo of this kind.

On October 5, 1922, Dr. James B. Paige, for sixteen years head of the Depa ment of Veterinary Science in the Station, passed away. Dr. Paige had be associated with this Station since its earlier years, and had always given mc valuable service. Alike for his thoroughgoing honesty and his sound comm sense, Dr. Paige will be sorely missed.

The position of Professor of Animal Pathology has been filled by the appoir ment of Dr. George Edward Gage, who is likewise head of the Department Veterinary Science and Animal Pathology.

On October 1 Dr. John B. Lentz was transferred from the position of Assista Research Professor of Veterinary Science to full-time member of the teachi staff, and Veterinarian of the College. In this position Dr. Lentz' training a experience will still be available to the Station. The position of Assistant Resear Professor of Avian Pathology has been created in place of that held by Dr. Len and filled by the appointment of Dr. Norman J. Pyle, a graduate of the Universi of Pennsylvania.

In the Control Service there have been a number of changes. Miss Ethel Bradley resigned July 15, 1922, as Analyst, with the position filled by the a pointment of Mr. Frank J. Kokoski. Mr. Ray A. Carter resigned in June, 19 as Collector of Blood Samples under the Poultry Disease Elimination Law, wi the position filled by the appointment of Mr. John J. Smith. Under date September 30, Miss Ann Smith, Analyst in the same service, resigned, with t position filled by the appointment of Miss Mildred H. Hollis.

During the year the title of Miss Sanborn, Clerk in the Department of Poult Husbandry, was changed to Investigator.

By action of the board of trustees, the Departments of Agronomy, Animal H bandry, Dairy Manufactures, Farm Management and Rural Engineering w recognized as Station departments, with the heads of these departments memb of the Station staff.

Publications of the Year.

Annual Report.

Thirty-fourth annual report:

Part I. Report of the Director and Other Officers; 79 pages.
Part II. Detailed Report of the Experiment Station; 168 pages (Bulletins 201–2
Combined Contents and Index, Parts I and II; 20 pages.

Bulletins.

No. 207. Injury to Foliage by Arsenical Sprays. I. The Lead Arsenates, by H. T. Fernald and A. I. Bourne; 20 pages.
No. 208. Leaf Characters of Apple Varieties, by J. K. Shaw; 12 pages.
No. 209. Experiments in Soil Management and Fertilization of Orchards, by J. K. Shaw; 28 pages.
No. 210. Injury to Foliage by Arsenical Sprays. II. Calcium Arsenates and Arsenites. III. Notes on Other Arsenicals, by H. T. Fernald and A. I. Bourne; 10 pages.
No. 211. Changes in Egg Production in the Station Flock, by H. D. Goodale and Ruby Sanborn; 28 pages.
No. 212. A Thirty-Year Fertilizer Test, by Sidney B. Haskell; 32 pages.

Bulletins, Technical Series.

No. 5. Concerning the Diagnosis of *Bacterium pullorum* Infection in the Domestic Fowl, by George Edward Gage; 28 pages.

Bulletins, Popular Edition.

No. 211. Changes in Egg Production in the Station Flock, by H. D. Goodale; 8 pages.

Bulletins, Control Series.

No. 18. Control of Bacillary White Diarrhœa, 1920–1921, by G. E. Gage, 8 pages.
No. 19. Inspection of Commercial Feedstuffs, by Philip H. Smith and Ethel M. Bradley; 34 pages.
No. 20. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, and R. W. Swift; 42 pages.
No. 21. Inspection of Lime Products Used in Agriculture, by H. D. Haskins, L. S. Walker and R. W. Swift; 8 pages.
No. 22. Control of Bacillary White Diarrhœa, 1921–1922, by G. E. Gage and O. S. Flint; 8 pages.

Meteorological Reports.

Nos. 397–408, inclusive, 4 pages each.

Control Activities.

Through State law, four different control activities are now being operated and administered by the Station: these being the feed and fertilizer control laws, the law for the inspection of dairy glassware, and the poultry disease elimination law. Reports on the first two activities have been published in Control Bulletins Nos. 19, 20 and 21, and that of the poultry disease elimination law in Control Bulletin No. 22. Since these reports give full details of the operations in 1922, no further mention need be made in this place. The activities under the law for the inspection of dairy glassware are similar to those of preceding years.

In addition to the above, the Station also administers the advanced registry testing work for several different breed associations. This is operated as a trust fund, the work being billed at cost plus ten per cent to allow for overhead. This fund now pays the salary of a full-time assistant, who cares for the routing of the men, keeping of the records, and other work of this nature. The Experiment Station acts only as a neutral, disinterested party for determining certain stated facts. It guarantees nothing other than the accuracy of records taken under its immediate supervision.

Extension Phases of Station Work.

As in previous years the time of several of the Station men, available for research work, is seriously diminished by calls for extension service. This is particularly the case in the Department of Veterinary Science, which in the spring of the year receives numerous calls for examination of dead chicks and dead fowl. In the Department of Botany many calls come for diagnostic service on plant

diseases; and in the Department of Entomology, for similar service in respect injurious insects. Work of this sort is essential and is not duplicated by any exis ing commercial organization. It is probably impossible, or if not impossible least impracticable, to divorce investigational work entirely from educatior work of this character. It should be recognized, however, that diagnosis ai analysis serve only as means to the end of improvement in certain directior As a matter of institutional policy, it is probable that, as soon as work of this ki develops so as to be a serious drain on our investigational forces, it should organized under the Extension Service. This need is recognized by the Extensi Service, and will be met as soon as funds are available.

Co-operative Organization of Extension Demonstration Projects.

Since the Station finds it necessary to do some extension work, it follows once that a certain amount of research work, at least of fact-finding work of survey type, may have to be done by our Extension forces. This has been pa ticularly the case in the field of farm management, and the technical subjects agronomy, pomology, vegetable gardening and poultry husbandry. The fie demonstrations operated by some of these departments should give valual data worthy of permanent preservation. This value, however, depends alwa on the authority back of the records taken. In order that this work may be bett done, and to insure preservation of such records as have value, some of the demonstrations have been organized in the Station as co-operative projects. T leader of these projects must make himself responsible for the accuracy of t work. Unless he can vouch for the records presented they cannot be accepte It is too early as yet to speak of the success or failure of this plan. There a however, seven projects organized on this basis, as follows:

"Poultry disease prevention and eradication"	Extension Professor Monahar
"Artificial illumination of poultry"	Extension Professor Monahar
"The use of nitrate of soda in apple orchards"	Extension Professor Van Met
"Controlling peach borers"	Extension Professor Van Met
"Thinning apples"	Extension Professor Van Met
"Comparison of results obtained in spraying with spray rod and spray gun"	Extension Professor Van Met
"Investigation of farm organization and labor efficiency on Massachusetts farms"	Professor Foord.

In addition to the above there are two other co-operative projects in which t expenses are met by the Station, but the salaries paid from other funds. One these is the "Boston food supply study" carried out under the leadership of I McFall; the other, "Testing low lift pumps" with the work done by the memb of the Department of Rural Engineering under the leadership of Professor Gunne These two projects are recorded in the reports on our investigational service.

REPORT ON PROJECTS.

Plant Nutrition and Soil Fertility.

The problem of soil fertility is dominant in every agriculture. It becomes mo difficult as soils become older and agriculture becomes more intensive — a Massachusetts soils are old soils, and its agriculture is becoming more and mo intensive. Orcharding, vegetable gardening, specialty vegetable growing su as asparagus growing or onion production, tobacco culture, cranberry culture these are typical of the agricultural activities developing in the State. The fertili problems incident to the growing of these crops differ very greatly from those the general farm. But even on the livestock farm there are some difficult problen particularly on our permanent pastures. For all of these reasons, therefore, it but natural and normal that a very large part of the Station resources should

used in the study of soil fertility and plant nutrition problems. These various projects group themselves into three major classes: (1) fundamental problems of the soil and plant, studied through the Departments of Botany and Plant and Animal Chemistry; (2) problems in fertility practice, studied through the Departments of Agronomy, Pomology, the Cranberry Station and the Market Garden Field Station; and (3) investigation into the nature and value of fertilizer materials, carried out in conjunction with the Fertilizer Control, through the Department of Agriculture.

A complete list of fertility and nutritional projects under way follows, together with a brief report of progress during the past year.

Chemical Investigations.

Chemistry Project 6. "Lime absorption and acidity of Field A."

Professor Morse and Assistant Professor Jones.

The numerous analyses of the drainage waters from the plots of this field have been co-ordinated, and have been found to give consistent results which show that the use of ammonium sulfate exhausts the calcium carbonate much more rapidly than is the case where no nitrogen has been applied, while sodium nitrate removes less calcium carbonate than either treatment. This is true at all seasons of the year when water has flowed from the drains. Determinations of residual calcium carbonate in the soils of the different plots corroborate results from study of the drainage waters. Calcium carbonate is more abundant in the soil which has received sodium nitrate than in that with no nitrogen treatment, while it is lowest in the soil that has received ammonium sulfate. The cause is due partly to the character of the chemical and partly to the difference in amount of nitrification induced in the soils.

Chemistry Project 7. "Effect of sulfate and muriate of potash on the soils of Fields A and B."

Professor Morse and Assistant Professor Jones.

The work on winter injury of brambles is directly connected with this project.

Analyses of twigs and canes from currants, gooseberries and blackberries which have grown on soils fertilized with one or the other of the two potash salts have resulted in some evidence that there is a difference in composition produced by the different fertilizers. The proportion of sugar has been consistently lower in the wood of the various plants grown on the muriate treated plot. Starch and pentosans are not so consistent, which is possibly due to two causes: the actual differences in these constituents may not really be very wide; the methods for their determination are much more approximate than those for sugars. A qualitative comparison of the chlorine present in the ash of the two series of crops shows a much more pronounced test for the element in the series on muriate. This shows an actual absorption of chlorides.

It is fitting to remark here that the work so far can be regarded only as exploratory in character.

Chemistry Project 14. "A study of the availability of soil potash, with the object of developing a system of diagnosis for soils of the State."

Professor Morse.

Pot experiments were conducted by Mr. Coffin with similar results in growth to those obtained last year. Analyses of the crops have not yet been made.

Microbiological Investigations.

Microbiology Project 2. "Soil fertility as influenced by micro-organisms in their relation to the presence and disappearance of organic matter."

Assistant Professor Itano and Mr. Sanborn.

Several phases of this problem have already been worked out. Two papers were presented at the annual meeting of the Society of American Bacteriologists, and may be found in the following sources of information:

1. "A Micro Electrometric Method for Determination of CO_2." Abstracts of Bacteriology, V, 1, 1921, p. 5.

2. "Influence of Vitamin and Nucleic Acid on Azotobacter." Abstracts of Bacteriology, VI, 1, 1922, p. 16.

One other paper has been prepared: "The Relation of Hydrogen Ion Concentration to Azotobacter Chroococcum, Beijerinckii and Vinelandii." This was carried out in co-operation with Professor U. Yamagata of the Imperial University of Tokyo, Japan.

The work now in progress includes:

1. A study of the influence of various cover crops on Azotobacter.
2. Study of the enzymes of Azotobacter.
3. A study of the influence of various ions on Azotobacter.

In addition, the study of microbial decomposition of cellulose has been developed as far as time permits, and now includes a physiological study of the organisms isolated, and of the rate of decomposition under various conditions.

Physiological Studies.

Botany Project 1. "Optimum conditions of light for plant response."
Assistant Professor Clark.

The work under this project is conducted in field, greenhouse and laboratory. In the field, various crops have been grown under three different light intensities: (1) normal light; (2) light reduced in intensity by one layer of cheesecloth; (3) light reduced by two layers of cheesecloth. The object is to determine whether the light factor has any decided influence on the production of seed and on the growth and vigor of resulting seedlings. Seeds and tubers produced this year will be planted next year under normal and modified light conditions. Plants of the biennial type are in storage and will be replanted next year for seed production under the same light conditions in which they were grown this year. Immediate as well as cumulative effect of light intensity is under study in this phase of the work. The field space devoted to the project was considerably enlarged this year.

In the study of the influence of ultra-violet light on plant growth, little of consequence has developed. A new type of glass which absorbs both heat and the ultra-violet rays has been obtained and is being used in this work.

Study of the effect of red light in the stimulation of photosynthesis is also in progress.

Botany Project 15. "A study of plant stimulation by formaldehyde."

This project is temporarily suspended owing to changes in the staff.

Pomology Project 1. "Study of the interrelation of stock and scion in apples."
Professor Shaw.

This project was begun in 1912, and the main orchard set in 1915 and 1916. It is too early as yet to make even a progress report on this work.

Pomology Project 12. "Apple variety fruit spur study."
Professor Shaw and Assistant Professor Drain.

Certain phases of this general study have been taken over by Professors Mack and W. K. French. The former has studied the spur bearing habits of several standard varieties of apples, while the latter has investigated the effect of fertilizers on growth and fruit spur formation. Spur samples collected during the summer of 1921 are still awaiting analysis.

Pomology Project 14. "Winter injury of brambles."
Professor Shaw, Professor Morse and Assistant Professor Clark.

This project, co-operative between the Departments of Botany, Chemistry and Pomology, was organized to investigate the cause of the winter-killing of brambles as apparently brought about by differential fertilization with potash salts. See report on Chemistry Project 7, page 7*a*.

Samples of wood growth were taken in the autumn of 1921 from the two potash plots and analyses have been made. Pentozan determinations by the furfurol method failed to indicate a higher content on the hardier plants from the sulfate plots. Studies by Professor Clark on herbaceous plants gave negative results.

Soil Management and Fertilizer Tests.

Agriculture Project 1. "Comparison of nitrogenous fertilizers."
Assistant Professor Gaskill.

This field has the longest continuous history of any now in the control of the Experi-nent Station. Unfortunately, however, three plots have had to be discontinued, ıamely, the two which received nitrate of soda as the source of nitrogen, and the one reated annually with barnyard manure. The proximity of the new chemical labora-ory may, indeed, make it necessary to discontinue the whole project.

Agriculture Project 3. "Residual value of excess phosphate applications."
Assistant Professor Gaskill.

In the project attempt is being made to utilize reserves of phosphoric acid built up in he soil from past fertilizer treatment. During the season just past, the crop of hay produced on residual phosphorus was so nearly like that on the area having current ap-plications, as to indicate rather marked utilization of phosphoric acid reserves.

Agriculture Project 4. "Methods of applying lime, and quantity of applica-ion."
Assistant Professor Gaskill.

No crop was produced on this field during the season just past, owing to the failure f the alfalfa seeding on account of wet weather.

Agriculture Project 6. "Top-dressing permanent grasslands."
Assistant Professor Gaskill.

The crop of 1922 is the second in this test. The experiment will be discontinued after ıe 1923 crop is harvested, as it should then be possible to estimate the cost of bringing ack "run-out" mowings through resort to commercial fertilizer top-dressing rather ıan to plowing and reseeding.

Agriculture Project 7. "An attempt to restore productive fertility to worn-out nd maltreated soils."
Assistant Professor Gaskill.

The use of a ton per acre of a complete fertilizer of an approximate 5–8–8 grade gave arked results in the second year of an attempt to "bring back" land which had reached ıe lowest level of infertility. The crop was mangels, late sown. On land which had ecome so poor as to give scarcely more than five bushels of corn to the acre, the yield as 18 tons; while where the land had received manure every year for thirty years, the eld was only 20 tons. On land unfertilized and unmanured for thirty years, crops of ? to 15 tons were secured.

Botany Project 13. "Ecological study of pasture vegetation."
Professor Osmun and Director Haskell.

The use of chemical fertilizers and lime on areas of an old permanent pasture badly fested with running cinquefoil and with moss resulted in a rapid change of the pre-ominant vegetation to white clover. The combination of potash and phosphoric acid as most effective, although maximum effect was not obtained without the use of lime plied as a top-dressing. Thus far it has been impossible to measure the effect of trogen. The precise relationship between the occurrence of certain plants and nu-ient conditions as influenced by artificial treatments has not yet been developed.

This investigation is now being enlarged to measure the results of treatments a also the effect, if any, of treatments applied at different times, particularly in late f or winter.

Market Garden Field Station Project 1. "Manure economy tests."
Professor TOMPSC

The progress of this work, developed as it was to find an answer to the problem rais by increasing shortage of animal manures, indicates that the amount of manure or narily used by vegetable gardeners may be cut in half, the difference being made up chemical fertilizers, without loss of crop and in some cases with significant decrease cost of production.

Market Garden Field Station Project 5. "Growth control by means of int cropping."
Professor TOMPSC

This project represents an attempt to better the condition of soils given up to pern nent onions, through the systematic use of inter-sown cover crops. The records of t year were spoiled, however, because of attack of the onion maggot and the resulta spotted stand.

Pomology Project 5. "Comparison of cultivation and sod mulch in a beari orchard."
Professor SHAW and Mr. FREN

This project, started in the spring of 1921, attempts to find the difference in effe on growth and production between cultivation in a bearing orchard and the use of nitr of soda in conjunction with a sod mulch. The sod plots were seeded to grass in Ju and the application of nitrate of soda was reduced from 300 to 150 pounds per ac The percentage of bloom was taken on all trees and the percentage of set on certain tr of each variety and treatment, as well as the regular growth and yield records. T trees on the areas seeded to grass (to which nitrate of soda was applied) on the wh bloomed heavier, set a little better and yielded considerably more than the trees in cultivated plots (which received no nitrate of soda). The grass sod can hardly be pected to show any pronounced effect before the 1924 crop.

Pomology Project 6. "Comparison of clover and grass in a sod mulch orchar
Professor SHAW and Mr. FREN

The trees in the sod mulch plot receiving nitrogen have already shown the influe of the fertilizer. Up to date there are no clover residues on the potash and phosph acid plot which could have had effect comparable with that of applied nitrogen. I interesting to note that under the proposed comparative treatments, that is grass p nitrogenous fertilizer on the one hand as compared to clover with potash and phosph acid on the other, the latter system is handicapped at the very start.

Pomology Project 7. "Test of fertilizers in a sod mulch orchard."
Professor SHAW and Mr. FREN

This orchard was seeded to grass in the fall of 1921, and the fertilizer application 1921 repeated this year. While no effect of the fertilizer could be seen last year, th was a marked response by the trees on all the fertilizer plots this year as indicated darker leaf color than that of the check trees. The regular records of growth, blo and yield have been taken.

Pomology Project 8. "Test of cover crops for apple orchards."
Professor SHAW and Mr. FREN

This project has been continued as last year, using the same cover crop with sim results. Timothy and redtop mixture was so promising that it was used in two of larger orchards to try it out on a more extensive scale.

Pomology Project 15. "Orchard fertilization."

Professor Shaw.

The records of this orchard for thirty years, together with those of the Graves Orchard in South Amherst, have been studied and published in Bulletin No. 209. The new schedule of fertilizer applications has been continued and the usual records taken. The Rhode Island Greening trees bloomed heavily but there was a light set. The Baldwins, on the other hand, set heavily from a sparse bloom. The yield from the check plot was very light, due to a combination of light bloom, poor set and small fruit.

Pomology Project 16. "Test of different amounts of nitrate of soda."

Professor Shaw and Assistant Professor Drain.

The regular fertilizer applications have been made, and growth and yield records taken.

Pomology Project 20. "Test of fertilizers for pears."

Professor Shaw.

While the apple and pear are closely related botanically, it does not necessarily follow that they require the same fertilizer program. A pear orchard about six years old and about an acre in area, growing in sod, was divided into three parts in the spring of 1922. One part received nitrate of soda at the rate of 300 pounds per acre; the second part, a complete fertilizer of 300 pounds nitrate of soda, 300 pounds acid phosphate and 200 pounds sulfate of potash per acre; while the third part remained without fertilizer as a check. There was a prompt nitrogen response by the grass, but the trees showed slight if any response as indicated by leaf color. Growth and yield records of individual trees are kept as in other blocks.

Pomology Project 19. "Study of the effects of fertilizer limitation on fruit plants."

Professor Shaw.

The field known as the North Soil Test field, which has had a continuous history of over thirty years, has been set aside for work with fruit plants and was planted in the spring of 1922 to apples, peaches, grapes and currants. The fertilizer applications are being continued as before and are as follows:

Plot 1. No fertilizer
2. Nitrate of soda
3. Acid phosphate
4. No fertilizer
5. Muriate of potash
6. Nitrate of soda and acid phosphate
7. Nitrate of soda and muriate of potash
8. No fertilizer
9. Acid phosphate and muriate of potash
10. Nitrate of soda, acid phosphate and muriate of potash
11. Land plaster
12. No fertilizer
13. Nitrate of soda, acid phosphate, muriate of potash and dried blood.

The west halves of all plots have been limed from time to time, most recently in 1914.

While this field presents very abnormal conditions, it was felt that it should give some valuable information of the fertilizer needs of fruit plants.

No responses to fertilizer treatment were seen before mid-July, but from then on there were gradually increasing differences between the trees on the different plots. It was evident that nitrogen and potash were both needed for the peach trees. There was nothing to indicate that phosphorus was needed by the peach trees even on those plots that had had no addition of phosphorus for thirty years. Indeed the peach trees on plot 3, receiving only acid phosphate, were inferior to those on the check plots and especially so on the limed portion.

Pomology Project 18. "Comparison of cultivation and heavy mulching fo apples and pears."

Professor Shaw

Two one-half acre blocks, one of Wealthy apple and the other of McIntosh appl interplanted with Bosc pear, were divided into two parts, and one-half of each carrie on the cultivation and cover crop system and the other half heavily mulched with swal hay from the neighboring lowlands. Fertilizers will be used as they seem necessary This project is related to Projects 5, 6, 7 and 8 discussed above.

Crop and Crop Management Studies.

The studies carried on under this head are devoted mainly to the genera problem of improving on existing conditions. Attempt is made to determine th adaptability of new crops as they may be introduced into Massachusetts, to fin improved varieties, and to enable farmers to make selection among varietie offered; and to breed better varieties. There is also included in this group o studies work designed to develop better methods of handling our present crops.

The work under way in these several lines is as described in the following:

Plant Introduction.

Cranberry Station Project 5. "Blueberry investigations."

Professor Franklin

This project was commenced in 1915, and is co-operative with the Bureau of Plan Industry of the United States Department of Agriculture. Preliminary tests with fer tilizers were started during the year, and extensive budding continued. Planting an budding have both gone about as far as present facilities permit. More land and propagating house are needed for this work.

Pomology Project 17. "A study of the cultivation of the high bush cranberry.'

Professor Shaw

Two hundred plants of Viburnum were received in the spring of 1921 from the Unite States Department of Agriculture and set out. A few of these plants bore a few cluster of berries. As soon as a crop is produced, affording a basis for selection, it is expecte to carry out some work in propagation of desirable types.

Strain and Variety Tests.

Agriculture Project 5. "Test of meadow fescue *versus* timothy under varyin drainage conditions."

Assistant Professor Gaskill and Mr. Coffin

The 1922 hay crop did not show any great superiority of one grass as compared to th other. Timothy gave the larger crop on the wetter portions of the field, the fescue out yielded the timothy on the drier portions.

Agronomy Project 1. "Investigation of the value of Hubam or annual swee clover as compared to the biennial sweet clovers."

Professor Michels

The spring seeding of both the annual and the biennial sweet clovers was a failure possibly due to the late date of sowing. Germination in the late summer season wa poor. The yellow sweet clover had such a weak growth as to indicate no value. It wil be discarded from future tests. The Hubam made a much heavier, fuller top growt than did the biennial clover, but on the other hand the root growth of the latter wa much the larger.

Market Garden Field Station Project 4. "Variety and strain test of tomatoes."
Professor TOMPSON.

Uniformity in growth conditions for the plants worked with in this test was prevented by an exceedingly high wind storm a few days after the plants were set. For this reason records of growth and behavior were not taken.

Pomology Project 2. "A study of tree characters of fruit varieties."
Professor SHAW and Mr. FRENCH.

Bulletin 208, "Leaf Characters of Apple Varieties" has been prepared and published during the year. The nursery certification work which has grown out of this project is developing and about 10,000 trees were examined this year. It is hoped to undertake further work with bud, bark, wood and growth habits this winter.

Pomology Project 13. "Study of varieties of tree fruits."
Professor SHAW and Assistant Professor GOULD.

Records of date and amount of bloom of practically all varieties of tree fruits on the college grounds, and individual tree yields have been secured for the season of 1922.

BREEDING.

Market Garden Field Station Project 6. "Improvement of Martha Washington asparagus."
Professor TOMPSON.

The second-year records of the 1,062 asparagus plants being studied in this investigation indicate that the comparative behavior of individual plants is fairly constant. The records also indicate a difference both in yield and in quality of product, due to the sex of the plant, which is the exact opposite of what was formerly thought to be the case. Thus far no practicable method of vegetative propagation of high yielding plants has been found.

Pomology Project 3. "The genetic composition of peaches."
Professor SHAW.

1922 failed to give a crop in this orchard. The trees are now old enough to warrant actual crossing work, which will be attempted in the spring of 1923 in case the fruit buds survive the winter.

ORCHARD MANAGEMENT.

Pomology Project 4. "Experiments in pruning apples."
Professor SHAW.

The average weight of 300 trees removed in the spring of 1922 indicates that the general law that pruning decreases tree growth in direct relationship to its severity holds as far as the trees under experiment were concerned.

Pomology Project 9. "Testing methods of pruning" and Pomology Project 10. "Testing of pruning methods on Northern Spy and other varieties."
Professor SHAW.

The time of summer pruning in Project 9 was changed from August to May, the purpose being to prevent undesired growth rather than remove it after it was made.

The Spy trees in Project 10 bore a small crop of apples. There seemed to be little if any benefit from either of the two pruning methods used over the unpruned trees, either in size of crop or quality of fruit.

Crop Protection.

As agriculture becomes more intensive, its susceptibility to disease and insec attack usually becomes greater. This is particularly the case in Massachusetts which, because of its situation on the channels of world commerce, is open to injur from accidental importation of foreign insects and diseases. It is probable that a time goes on there will be increasing necessity of studies relative to crop protection This is due in part to the danger of introduction of new diseases, and secondly t the fact that increasing value of farm crops brings about increased financial los when these are damaged by fungous diseases or insect enemies.

Insect Enemies of Vegetation.

Entomology Project 2. "Economic importance of digger wasps."
Professor Fernald

Because of the pressure of other duties, no work was done on this project, during th 1922 season.

Entomology Project 3. "Control of the onion maggot."
Assistant Professor Bourne

Weather conditions the past year were such as to make the stand of onions on th experimental fields so variable as to make the records valueless for experimental pur poses.

Entomology Project 4. "Control of squash vine borer."
Mr. Worthley

Tentative control measures which were developed during 1921 were tried on a com mercial scale at Amherst and at Lexington. The cost of such treatments was determined The seasonal history of the borer in Amherst was compared with its history at Lexingto so that control measures may be so timed as to be applicable to the Boston Marke Garden District as well as to the Connecticut Valley.

Entomology Project 5. "Control of the squash bug."
Mr. Worthley

The main effort has been to find a material toxic to the adult bugs but not toxic t the plants. To date these efforts have been only partially successful. The life histor of the Tachinid parasite of the squash bug, *Trichopoda pennipes*, has been worked out and its relation to its host determined. Papers on the life history of the squash bug i Massachusetts and the control measures tried, and on the parasite, are being prepare for publication.

Entomology Project 7. "Studies of insect outbreaks in various localities."
Professor Fernald

This is a continuing project, the subject being entirely dependent upon the insect which may appear. In 1922 the conditions as related to the corn ear-worm and see corn maggot, which were the insects studied in 1921, were continued and concluded and the appearance of the birch leaf skeletonizer and the apple and thorn skeletonize led to their study as well.

Entomology Project 8. "Pest limits in Massachusetts."
Professor Fernald

Data on this subject are gathered each year as they appear and can be obtained Some additions were made in 1922.

Entomology Project 9. "Number of generations of codling moth in Massachusetts as related to advisability of spraying for the second generation."

Assistant Professor BOURNE.

The accumulation of data on the codling moth has now reached a point where, with good fortune, final results may be anticipated in the course of two or three seasons. Co-operative work with a fruit grower in the Nashoba fruit district has added value to the work, giving a broader knowledge of conditions in Massachusetts.

Entomology Project 10. "Hatching dates for scale insects."

Assistant Professor BOURNE.

The necessary observations for 1922 have been made and recorded. To be of value, these records should be made over a long period of years, to insure inclusion of years of abnormal conditions as well as normal ones. The behavior of the insects under normal conditions has been determined with considerable accuracy. Their reaction to abnormal seasonal conditions, such as very open, mild winters, or unusually cold winters, makes further study advisable. Records on other points in the life cycle of these scales have been secured, with especial reference to the possibilities of their furnishing more accurate data on this problem.

Cranberry Station Project 1. "Injurious and beneficial insects affecting the cranberry."

Professor FRANKLIN.

The more important results of the year's operations were the following:

A very effective control for the root grub (*Amphicoma vulpina* Hentz.), by soaking the soil with a solution of sodium cyanide, was developed.

A satisfactory control for the yellow-head fireworm (*Peronea minuta* Rob.) by killing the moths with a spray of nicotine sulfate and soap in the dormant season was perfected. Experiments also showed that this pest can be controlled with a lead arsenate spray used at the time and strength to be most effective against the gypsy moth.

It was found that the red-striped fireworm (*Gelechia trialbamaculella* Cham.) can be controlled well with a nicotine sulfate and soap spray applied while the worms are in the tips of the vines.

Dusting with nico-dust to control the black-head fireworm (*Rhopobota naevana* Hübner) proved effective but not practicable because of the expense.

Extensive spraying experiments to discover a cheaper control for black-head fireworm were conducted, with mostly negative results.

A fungus, apparently a new species of *Entomopthora*, was found causing such an epidemic among the black-head fireworms on one bog that it seemed an almost perfect control. The fungus was successfully cultured on fish. It presents interesting possibilities for further control work.

Important observations were made on the phenomenon of the occasional marked disappearance of black-head fireworm eggs while covered by the winter flood.

Many new facts were learned concerning the life histories of the following minor cranberry pests:

1. *Cacoecia parallela* Rob.
2. *Sparganothis sulfureana* Clemens.
3. *Noctua c-nigrum* L.

The work of the fruit worm (*Mineola vaccinii* Riley) was observed to be light in spite of the fact that the egg parasite (*Trichogramma minuta*) was much less prevalent than normally. The egg hatching of this pest was earlier than usual, so the worms did little harm among stored berries. Further attempts to discover a practicable means of control by wetting the cocoons with chemicals during the dormant season resulted negatively.

PLANT DISEASE CONTROL.

Botany Project 3. "Tobacco investigations and a study of so-called tobacco sick soils."

Professor OSMUN and Professor ANDERSON.

This project embraces a study of soil reaction as a means of controlling root-rots of tobacco; also a study of the effects of soil reaction on the growth and development of

tobacco. During the last season, further study was made of the influence of cover-cro ping and liming on the development and effect of black root-rot, caused by *Thielav basicola,* and considerable data were obtained. An important feature of this yea field work was the successful infestation by artificial means of experimental field plo with Thielavia. With permanent plots known to be infested with this fungus and othe free from it, valuable results should be obtained in the next few years.

Botany Project 4. "Investigations of the methods of controlling lettuce drop Professor OSMUN and Assistant Professor KROU

The work on this project has been completed. The investigation involved prelim nary study of the reaction of the drop fungus, *Sclerotinia libertiana,* to various facto and extensive testing of these factors in their relation to the control of the disease in t greenhouse. The net practical result is the definite determination that the disease m be controlled with relatively little expense by treating infested soil with formaldehyd A 1–100 solution applied to the surface of the soil at the rate of one gallon to the squa foot was found efficacious. It was found also that treatment must begin in the see bed to prevent infection of young plants before transplanting to the main house. D tails of practice were worked out in some of the commercial houses of the State.

Botany Project 5. "Experimental spraying for the control of cucumber milde under glass."

Assistant Professor KROU

Bordeaux gave slightly better results this past season than did a copper-lime du Full control, however, is not yet obtained.

Botany Project 6. "Investigation of onion diseases." Professor OSMUN and Professor ANDERSO

As stated in the last report, the work on this project has been focused on a study onion smut and its control. Technical Bulletin No. 4, "Development and Pathogene of the Onion Smut Fungus", distributed early in the present year, is a report of som of the more technical features of this work. Field tests of formaldehyde applied different concentrations and rates were continued this year. In co-operation with t Department of Rural Engineering, the apparatus for applying formaldehyde has be perfected to the extent that errors due to uneven distribution of the fungicide have be eliminated. The development of this equipment renders advisable the continuance field tests for at least one more season. The use of the new equipment by practi growers gave some very interesting and significant results.

Botany Project 9. "Investigation of carrot blight."

Assistant Professor KROU

The work on this project was conducted along the same lines as reported last ye Considerable attention was given to study of the etiology of the disease and it has be definitely established that the pathogene is a Macrosporium. The incubation peri has been determined and physiological studies of the organism are in progress. In t field, considerable benefit was shown from spraying with Bordeaux mixture, but defin conclusions can be drawn only from the results of several years' work.

Botany Project 10. "Apple disease control investigations."

Assistant Professor KROU

The work on this project has been confined almost wholly to an investigation of t control of scab. Very satisfactory progress has been made and much of importance the practical orchardist has resulted. It has been definitely established that the McI tosh apple, which is very susceptible to attack by scab, can be protected against t disease by spraying with fungicides. Results from dusting also have been excelle but further tests are necessary. The best results have been obtained by the use of 3–10–50 home-made Bordeaux mixture for the pre-pink and pink applications, follow by liquid lime-sulphur, 1–50, for the summer sprays. The most satisfactory resu from dusting were obtained with finely ground sulfur. Copper-lime dust prov

effective in controlling scab, but serious russeting of the fruit by this material definitely eliminates it as a possible apple fungicide, at least for summer application.

Meteorological records were kept and important observations on the relation of meteorological conditions to sporulation, spore ejection and infection by the scab fungus were made. These data, taken over a series of years, will be invaluable in establishing a definite and permanent spraying or dusting schedule for the State.

Early in the year the leader of this project, Mr. W. S. Krout, established his residence in the eastern part of the State. This has enabled him to keep in more intimate touch with the field work and has made possible considerable expansion over last year's plan.

Botany Project 14. "Investigation of control of tobacco wildfire."
Professor ANDERSON.

The disease known as Wildfire has created a grave situation in the tobacco growing industry of the Connecticut Valley. The seriousness of the outbreak the last season, and consequent imperative need of solving the problem of control, made a constant demand on the time of the leader of this project, as well as of others of the department. The importance of thoroughly familiarizing himself with the disease, both in the seed-bed and field, kept the investigator out of the laboratory and on the tobacco farms a considerable portion of the time. In this way much information was gathered which will prove useful in the furtherance of the investigation.

Botany Project 16. "Relation of soil character to occurrence of onion smut."
Professor ANDERSON.

No progress on this project was made during the past year, on account of lack of time.

Cranberry Station Project 2. "Cranberry Disease Work."
Professor FRANKLIN.

This project was conducted, as heretofore, co-operatively with the Bureau of Plant Industry of the United States Department of Agriculture. Extensive culture work was done to discover the variation in the cranberry fungus flora among different classes of bogs, especially with reference to differences in their flooding.

Studies were pursued to determine more definitely the relationship of the weather to deterioration of cranberry keeping quality from the activity of putrefactive fungi.

Extensive tests were conducted to determine the effect on cranberry keeping of the Wisconsin method of picking known as "water-raking." This was found to be very harmful.

Extensive storage tests were also made to determine the effect on cranberry keeping of picking during the heat of the day as compared with picking late in the afternoon. The harmful effect of the former was clearly demonstrated.

SPRAY MATERIALS — THEIR NATURE AND USE.

Botany Project 17. "Potato spraying-dusting."
Professor OSMUN and Professor ANDERSON.

This project has for its main object the making of comparative tests of home-made Bordeaux mixture and copper-lime dusts for combating late-blight and other leaf diseases of the potato.

The conclusions from the first year's work are:

1. Dusting with hand dusters has not been as efficient as spraying with a power sprayer.
2. Dusting by hand costs more than power spraying.
3. The percentage of rotten potatoes was higher in the treated plots than on the check plots. This was probably due to the fact that the vines on the check plots dried earlier and the moisture conditions were then less favorable to development of the disease than where the soil remained covered several weeks longer with a dense mat of vines.
4. Both spraying and dusting resulted in considerable increase in yields over the checks. Spraying gave the greater increase.

Chemistry Project 5. "Chemistry of arsenical insecticides."
Professor HOLLAND and Mr. DUNBA

This project is no longer confined to arsenical insecticides, but has practically becom a study of the chemistry of insecticides and fungicides. The work is in large measu co-operative with other departments of the State and Station, and is largely confine to analytical work.

It has furnished needed information relative to various types of commercial sulf compounds, although as yet scientific entomological and pathological data are lackin for the interpretation of analytical results in terms of toxicity, or preferably of efficienc This in a measure is also true of waste tobacco.

Chemistry Project 13. "A new method for the analysis of dry lime-sulf mixtures."
Assistant Professor JONE

Work on this project has been completed, and report submitted for publication.

Chemistry Project 20. "A study of the fundamental factors affecting the su pension, adhesiveness, toxicity and general efficiency of copper fungicides."
Professor HOLLAND and Mr. DUNBA

The work outlined is very extensive, including chemical, physical and pathologic studies of a considerable variety and large number of compounds, requiring more or le co-operation by the Departments of Botany and Physics, and final verifications by fie experiments. A portion of the literature has been reviewed, preliminary work on pr duction of some of the compounds undertaken, stability and certain physical properti have been noted, and hundreds of suspension tests have been conducted to determi the effect of different amounts of lime under varying conditions and the influence protective colloids and deflocculating agents.

Entomology Project 1. "Studies of causes of burning of foliage by arsenicals
Professor FERNALD and Assistant Professor BOURN

This work has been completed, and Bulletins Nos. 207 and 210 of this Station gi the results with lead arsenate, lime arsenate and some other arsenicals. A third bu letin, on Paris green, is in preparation.

Entomology Project 12. "Determination of the best strength of lime-sulfur
Assistant Professor BOURN

Tests of various dry sulfids have been made under differing conditions, in comparis with different strengths of the liquid lime-sulfur. The tests have not sufficiently cover the ground as yet to make a report of results possible.

Entomology Project 13. "Study of the possible injurious effects of Scalecide trees."
Assistant Professor BOURN

Tests of this material must be continued for several years before results can be r ported.

Entomology Project 14. "Does spraying orchards kill bees?"
Assistant Professor BOURN

The investigations thus far have been quite suggestive, particularly indoor ones, b the inclement weather following the "calyx spray" out of doors last spring makes fu ther studies necessary.

Entomology Project 15. "Determination of efficiency of nicotine sulfate dusts
Assistant Professor BOURN

The nicotine sulfate dusts proved very effective in nearly all tests. The high pri of these dusts, however, often prohibit their use. Dusts of ground tobacco, reinforc

with nicotine sulfate did not give as satisfactory results, chiefly because of their inferior physical qualities. Comparative tests of superfinely ground tobacco dusts have been planned for another season.

Entomology Project 16. "Investigation of materials which promise value in insect control."

Assistant Professor BOURNE.

This is a continuing project covering materials as they may appear. This season two materials were tried out — Derris and Flyosan. The tests with Derris in its various forms were quite satisfactory as far as they went, and further tests of this material will be made the coming year. When these tests have been completed a final report on Derris can be made. Flyosan in some of the tests also gave good results, but more studies of it are necessary before full statements would be advisable.

Pomology Project 11. "To test new spray materials as they become commercially important."

Professor SEARS and Assistant Professor GOULD.

The following materials were tried out this year in comparison with standard liquid lime-sulfur and arsenate of lead: Bordeaux mixture 3–10–50, Nurexo Bordeaux Lead, Nurexo Spraydried, Celesto, Sulfurex, Sulfocide, Sulco V-B, Dry Lime Sulfur, Nurexoform Lead, Calcium Arsenate and Cal Arsenate.

While some of these materials gave good results, none of them gave promise of sufficient merit to replace liquid lime-sulfur and lead arsenate.

Animal Nutrition.

The use of purchased concentrates, mixed or unmixed, is the salient characteristic of Massachusetts animal industry. The cost to the industry, and finally, of course, to the consumer of its products, is immense; possible waste, in case the materials are unwisely used, or bought on the basis of ignorance instead of knowledge, enormous. The work of the Station in this direction has, therefore, two objectives: first, to develop a basis for the productive feeding of these articles; and secondly, to measure the characteristics of various feedstuffs, so that dairymen may have a sound basis of purchase.

DIGESTIBILITY OF FEEDING STUFFS.

Chemistry Project 2. "Digestion experiments."

Professor LINDSEY and Assistant Professor ARCHIBALD.

In addition to digestion experiments made in connection with projects 12 and 19, one experiment was made with cocoa dust, with results incorporated in manuscript already prepared on "Digestibility of Cattle Feeds."

Chemistry Project 9. "Determining the digestibility and metabolizable energy in feeds for horses."

Professor LINDSEY and Assistant Professor ARCHIBALD.

Final report is now being prepared for publication.

Chemistry Project 12. "Attempting to improve the nutritive value of grain hulls."

Assistant Professor ARCHIBALD and Professor LINDSEY.

Considerable progress has been made on this project. In addition to the treatment and determinations of digestibility of oat and rice hulls already reported, the following materials have been treated and the influence of treatment on digestibility determined: — namely, barley hulls, cottonseed hulls, and flax shives. In addition to the regular analysis, determinations of starch, galactan, pentosans, and lignin have been made on the natural and treated materials, and determinations of the above substances are now being made in the feces.

It can be said that the digestibility of the barley hulls has been greatly improve but the treatment has been substantially without effect upon the cottonseed hulls ar the flax shives. The method of treatment — namely, with dilute sodium hydrate would probably not prove economical on a large scale.

Animal Feeding.

Chemistry Project 10. "Experiments in feeding pigs."
Professor Lindsey and Assistant Professor Archibali

This project consisted in the taking of records on feeding different amounts of sem solid and dried buttermilk. Results indicate that these materials are uneconomic when used for pork production. Work under this project is completed, but resul have not yet been submitted for publication.

Chemistry Project 16. "Vitamines as aids in the production of growth in pigs.
Professor Lindse

As with the above, work has been completed, temporarily at least.

Chemistry Project 17. "Attempting to secure a substitute for milk in th growing of young calves."
Professor Lindsey and Assistant Professor Archibali

Four different materials or combinations of materials were used as milk substitute with a total of twenty-three calves used in the investigation, but with four discarde as unsatisfactory. In these different mixtures limited amounts of soluble blood flou dried skim milk, oat flakes, corn meal, wheat middlings, coconut meal, peanut mea linseed meal, starch, glucose, milk sugar, calcium chloride and salt were used. Fa results were secured.

Chemistry Project 18. "To determine the mineral constituents of forage crops.
Professor Lindsey and Assistant Professor Archibali

This study has been fruitful in two directions: first, the collection of about sixt samples of coarse fodders, principally hay and corn silage, from different parts of th State; and secondly, determination of the mineral constituents in the ordinary concer trates which are used in the State. It is expected that this work will be complete during the coming winter.

Chemistry Project 19. "The value of inorganic calcium phosphate in the pro motion of growth and milk production.
Professor Lindsey and Assistant Professor Archibali

Up to date no effect favorable or otherwise of feeding inorganic calcium phosphate t cows, young stock and sheep has been noted. Despite this failure, however, these in organic salts are widely used in the State as constituents of animal feeds. Their valu is yet to be proven.

Miscellaneous.

Chemistry Project 3. "Summer forage crops."
Professor Lindsey

Very little work was done on this project. There are no results worthy of extende comment.

Chemistry Project 4. "Record of the station herd."
Professor Lindsey

As in previous years complete records on the food cost of milk produced by the statio herd have been kept.

Studies of Heredity in Poultry.

The Massachusetts poultry industry is essentially intensive. It operates fairly large flocks, but on relatively small areas. Most of the food consumed is purchased, imported largely from the grain sections of the West. In order that the Massachusetts industry may compete with that of other sections of the country, it is necessary that the stock be of the highest possible grade. This fact gives a peculiarly important economic significance to the work grouped in the following:

Poultry Husbandry Project 1. "Broodiness in poultry."

Professor Hays.

The broody trait in poultry is being studied from the following angles:

1. Possibility of establishing a strain of broody-free Rhode Island Reds by systematic matings in pedigreed lines. An approach to this goal has been made in some families.
2. Specific intensification of broodiness by the pedigree system of matings.
3. The behavior of the factor or factors for broodiness in crosses.
4. The physical relationship of different organs to broodiness.

Poultry Husbandry Project 2. "To determine the mode of inheritance of various characters in poultry, and to study factors governing form and function."

Professor Hays.

The basic idea for which this project has been carried is the analysis of the mode of inheritance of factors for egg production. The results seem to indicate that at least four or five pairs of factors are concerned. Progress of a very definite character has been made by handling these factors as units in breeding.

Human Food.

The increasing cost of food products has brought about the necessity of more attention being given to the conservation of food. Conservation essentially requires control of those forces and agencies which cause decay and loss; and as a first step a study of the conditions under which these agencies develop. The very small amount of time given to this subject at this Station is not a measure of the importance of the work. In fact the well-being of the great food-consuming population of the State would be furthered were this work to be greatly increased.

Microbiology Project 1. "Microbiological investigations in milk."

Mr. Avery and Mr. Neill.

The following articles have been prepared during the year:

"A Biological Study of the Hemolytic Streptococci from Dairy and Human Sources: The Differential Reaction of Methylene Blue." Roy C. Avery.

"A Review of the Literature of Lactic Acid Fermentation." James M. Neill.

"A Study of the Characters of the Streptococci of Dairy Lactic Acid Fermentations, with Special Reference to the Present Status of the So-called *Streptococcus Lacticus* Group." James M. Neill and Roy C. Avery.

"A Comparative Study of Different Types of Streptococci, with Special Reference to the Peptolytic Activity of the Lactic Group." James M. Neill.

At the present time, however, this work is at a standstill, owing to the fact that the men involved have left the institution or become burdened with other work.

Microbiology Project 3. "Canning investigations in the light of normal and resistant organisms in continuous, fractional and pressure methods of sterilization."

Professor Marshall and Mr. McCrimmon.

The first stage of this investigation is practically complete, although verification of the results is essential and an extension of certain determinations must be made. It is, however, being retarded owing to the resignation of Mr. McCrimmon.

Agricultural Economics.

The status of agriculture at any particular time and place is always the resultar of economic forces working in conjunction with those other forces which contr the condition or productivity of the soil and the possibility of growing certa crops. Massachusetts has been slow to recognize this fundamental principle. has failed in supporting economic research in agriculture in the way which tl importance of the subject necessitates. The future of New England agricultu probably depends in large measure on economic conditions; and likewise tl future of New England and Massachusetts as industrial units depends on tl national development and maintenance of those economic conditions which w make possible continued production of food in suitable quantities. Much of tl high cost of living, of which we hear so much complaint, is due not to deficiency local production, but rather to avoidable waste in handling farm products.

Work has been done during the past year under the following projects:

Agricultural Economics Project 1. "Local balance of trade in farm products

Assistant Professor JEFFERSO

Study under this project has been continued. In addition to the material secur in Fitchburg, the gathering of similar information has been carried on in New Bedfo so far as it is available for that city.

The local farm products of the vicinity of New Bedford are sold in that market wit out system of any sort. These products are chiefly vegetables, although a small quanti of fruit is also grown. Each grower sells his own produce in the way which appeals him. Some few sell to the wholesalers, but the most common method is for the grow to stop at the first grocery store he reaches as he drives into the city, sell what he ca and go on to the next. Naturally, this brings each grower into competition with eve other, reducing the price each one receives.

No local products are shipped out of New Bedford, and the local production falls f short of supplying the needs of the city, except in the case of turnips.

A large part of the milk supply is likewise local, but considerable quantities are r ceived at certain periods from outside sources. Some of it comes from Maine and Ne Hampshire, but all is received through the Boston distributors.

There is very little local slaughtering done in New Bedford, although there are tv local slaughterhouses, one in the city and the other across the river in Fairhaven.

Agricultural Economics Project 2. "Methods and cost of distribution of tobacc onions and potatoes."

Professor CANCE and Assistant Professor JEFFERSO

An investigation of the supply and distribution of Connecticut Valley onions, alrea under way, was completed and the manuscript prepared for publication.

In addition to the preparation of this manuscript, material is at hand for a secon relating to the price of onions.

Agricultural Economics Project 7. "Boston food supply study."

Professor McFAI

This project was formally approved in July, 1922, on a co-operative basis betwe the Experiment Station and Extension Service. A large amount of time and energy h been expended in outlining the study and carrying on certain preliminary work. organized, the leader of this project spends a part of each week in Boston, overseei the work of a number of graduate students who are taking as their thesis problem certa of the subdivisions of the larger study. At the present time fourteen students are engaged: three being from Boston University and eleven from the Massachusetts Ins tute of Technology. Certain other investigators are likewise co-operating, but in informal way. The State Department of Agriculture is assisting in certain broa phases of the work. The committee on agriculture of the Boston Chamber of Co merce has co-operated in making a comparative study of the market reports of all pub and private agencies reporting Boston markets. A certain amount of the financing this work is done directly through a co-operative agreement with the Bureau of Ag cultural Economics of the United States Department of Agriculture. Naturally, in present formative stage, concrete results cannot yet be reported.

Rural Engineering.

The following project represents the first experimental work done by the Department of Rural Engineering since its formal organization as a Station department.

Rural Engineering Project 1. "Testing Low Lift Pumps."

Professor GUNNESS.

This project is co-operative between the Cranberry Station and the Department of Rural Engineering. It was made necessary by the fact that there has never been a comprehensive study made of the large capacity, low lift pumps as used so largely in the Massachusetts cranberry industry. The work occupied a large portion of the summer of 1922. Manuscript has been prepared and submitted for publication, the project in its present form being therefore complete.

Meteorological Studies.

The work of the Station in this direction consists in part of the taking of data at the home station as indicated by the following; and in part in the definite application of meteorological data to certain definite agricultural problems, notably that of cranberry bog management and secondly the relation of weather to insect development.

Meteorology Project.

The recording day by day of meteorological phenomena, and the publishing of monthly summaries for distribution to parties interested has been continued. The year just closed was the thirty-fourth over which this work has continued. When combined with the records taken by the late Professor Snell, the Station has an unbroken meteorological record of eighty-seven years. Work of this kind becomes more and more valuable as such records accumulate.

Entomology Project 11. "Study of area of the late frosts as shown by insect distribution."

Professor FERNALD.

More light on this subject has been obtained during 1922. It will require many years for completion, but takes annually only the time necessary to record the data obtained.

Cranberry Station Project 3. "Weather observations with reference to frost prediction."

Professor FRANKLIN.

As in past years, reports were telegraphed daily to the district forecaster at Boston. Further frost records were accumulated for study. Distribution of Station frost warnings was continued with the financial aid of the Cranberry Growers' Association.

METEOROLOGICAL OBSERVATIONS.

DEPARTMENT OF METEOROLOGY,

PROF. J. E. OSTRANDER, HEAD.

Annual Summary for 1922.

Pressure (in Inches).

Maximum reduced to freezing	30.36, Jan. 25, 10 A.M.
Minimum reduced to freezing	28.60, Oct. 11, 12 P.M.
Maximum reduced to freezing and sea-level	30.70, Jan. 25, 10 A.M.
Minimum reduced to freezing and sea-level	28.92, Oct. 11, 12 P.M.
Mean semi-daily reduced to freezing and sea-level	30.05
Annual range	1.7

Air Temperature (in Degrees Fahrenheit).[1]

Highest	94.0, July 12, 4.00 P.M.
Lowest	—13.5, Feb. 18, 7.30 A.M.
Mean hourly	47.2
Mean of means of max. and min.	47.8
Mean sensible (wet bulb)	43.0
Annual range	107.5
Highest mean daily	76.7, Aug. 16
Lowest mean daily	—0.8, Feb. 17
Mean maximum	58.3
Mean minimum	37.3
Mean daily range	21.0
Greatest daily range	43.5, Apr. 10
Least daily range	3.5, Nov. 7

Humidity.

Mean dew point	39.2
Mean force of vapor	380
Mean relative humidity	78.7

Wind.

Prevailing direction	West

Summary.

South Southwest	19 per cent
Northwest	12 " "
North	10 " "
West Northwest	10 " "
Southwest	10 " "
Other directions	39 " "
Total movement	49,970 m.
Greatest daily movement	467 m., Dec. 6
Least daily movement	12 m., Jan. 17
Mean daily movement	137 m.
Mean hourly velocity	5.7 m.

Maximum pressure per square foot, 30.0 lbs., =78 m. per hour, Jan. 22, 12 M., W.

Maximum velocity for 5 minutes, 42 m. per hour, Jan. 22, 12 M., W.; June 12, 2 P.M., W.N.W.

Precipitation (in Inches).

Total precipitation, rain or melted snow	45.9
Snow total in inches	58
Number of days on which .01 or more rain or melted snow fell	12

Weather.

Mean cloudiness observed	45 per cen
Total cloudiness recorded by Sun Thermometer	1,932 hrs. =43 per cen
Number of clear days	11
Number of fair days	12
Number of cloudy days	12

Bright Sunshine.

Number of hours recorded, 2,522 hrs. =57 pe cent.

Dates of Frosts.

Last	May 1
First	Sept. 1

Dates of Snow.

Last	April 2
First	Nov. 2
Total days of sleighing	7

Gales of 50 or More Miles per Hour

Jan. 22, 78 m., W.; Mar. 7, 63 m., S April 20, 53 m., W.N.W.; June 12, 56 m W.N.W.; July 8, 57 m., S.S.W.; Dec. 2 57 m., N.

[1] Temperature in ground shelter.

REPORT OF THE TREASURER.

FRED C. KENNEY.

United States Appropriations, 1921–22.

		Hatch Fund.	Adams Funds.
Dr.			
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1922 under acts of Congress approved March 2, 1887 and March 16, 1906		$15,000 00	$15,000 00
Cr.			
Adams:			
By salaries	$14,947 50		
Labor	52 50		
	$15,000 00		15,000 00
Hatch:			
By salaries	$14,632 50		
Labor	367 50		
	$15,000 00	15,000 00	

State Appropriations, 1921–22.

Cash balance brought forward from last fiscal year	–
Cash received from State Treasurer	$99,152 86
fees	18,648 95
sales	9,690 25
miscellaneous	378 20
	$127,870 26

Cash paid for salaries	$60,164 33
labor	17,459 50
publications	2,017 25
postage and stationery	1,767 69
freight and express	429 75
heat, light, water and power	745 56
chemicals and laboratory supplies	3,049 88
seeds, plants and sundry supplies	2,290 32
fertilizer	689 11
feeding stuffs	1,386 20
library	635 79
tools, machinery and appliances	1,167 54
furniture and fixtures	987 31
scientific apparatus and specimens	292 09
livestock	230 82
traveling expenses	4,819 60
contingent expenses	10 00
buildings and land	1,010 12
Remitted to State Treasurer	28,717 40
Total	$127,870 26

BULLETIN No. 207.

DEPARTMENT OF ENTOMOLOGY.

INJURY TO FOLIAGE BY ARSENICAL SPRAYS.

I. THE LEAD ARSENATES.

BY H. T. FERNALD AND A. I. BOURNE.

It has long been known that arsenical poisons sprayed upon foliage will at times produce injury, or a "burning" of the leaves. For this, four explanations have been offered, viz., (1) that the arsenic (either As_2O_3 or As_2O_5, as the case might be) was present in the material, uncombined with any base; (2) that it was so loosely combined with the base as to become liberated from it during the addition of water in preparing it for application to the foliage; (3) that this liberation took place more or less gradually on the leaves after the spray had been applied, as a result of influences acting upon the material through the air; and (4) that injury was due to the presence of injurious impurities in the material.

Faulty methods of manufacture might easily result in producing a substance containing some arsenic, either free or so poorly combined that upon the addition of water the combination would break up, at least to some extent. The use of poor materials from which to make the lead arsenate might very possibly result in the presence of injurious substances. The liberation of arsenic upon the tree by atmospheric influences, however, comes distinctly in a different class; and the statement sometimes made, that spraying a tree with water under the right conditions may result in burning, if true, also suggests that atmospheric conditions must not be overlooked. The entire problem, therefore, of ascertaining what factors are really responsible for foliage injury following arsenical spraying has been investigated during a period of about ten years.

This bulletin reports the results of this work with the various lead arsenates. Similar reports upon arsenates of lime and Paris green are nearly ready for publication, together with notes on a number of other arsenicals which have been tested more or less.

The planning of the project, the plotting and analysis of the results, and the preparation of the material for publication are the work of the senior

author; the preparation and application of the sprays, and the observations to determine their effects, were carried out by the junior author; the chemical analyses and all the chemical work involved were done by Dr. E. B. Holland and his assistants of the Department of Plant and Animal Chemistry of the Experiment Station, and to him and to those who worked with him the authors desire to express their appreciation of the efforts made to establish this work on a firm chemical basis.

MATERIALS.

To eliminate the possibility that injury was caused by impurities in the spray materials, pure arsenates were first sought. A definite knowledge of the action of these appeared to be desirable, as, if injury resulted from their use, it seemed probable that the factors causing it would be indicated, uncomplicated by the presence of injurious impurities, uncombined arsenic or too loosely combined arsenic. In fact, such knowledge would provide a basis or standard with which to compare results obtained from the use of commercial materials. Accordingly, the attempt was made to obtain pure acid lead arsenate and pure neutral lead arsenate.

To get these seemed at first to be almost impossible. A number of manufacturers were willing to supply them, but the samples received proved on analysis to be far from pure, and nearly two years passed before materials were found so nearly pure that it was believed they would be satisfactory.[1]

Pure Acid Lead Arsenate Paste. — The material used in these experiments analyzed as follows: —

	Per Cent.
Water, H_2O	46.99
Water in combination and occlusion	1.33
Lead oxide, PbO	34.58
Arsenic pentoxide, As_2O_5	17.11
Chlorine, Cl	.04
Insoluble matter	.01
	100.06

The probable original composition of the paste, reconstructed from this analysis, was substantially as follows: —

	Per Cent.
Water, H_2O	46.99
Water occluded	.09
Acid lead arsenate, $PbHAsO_4$	47.87
Neutral lead arsenate, $Pb_3(AsO_4)_2$	4.93
Lead chloride, $PbCl_2$	.16
Insoluble matter	.01
	100.05

[1] See Holland and Reed: The Chemistry of Arsenical Insecticides, Twenty-fourth Annual Report, Mass. Agr. Exp. Station, Part I, pp. 180–182, 1912, for a fuller discussion.

The impurities present here — the lead chloride and insoluble matter — occur in such infinitesimal amounts and are of such a nature that they certainly could not cause any injury on foliage.

As the purpose of using this material was to test acid lead arsenate, the presence of nearly 5 per cent of the neutral salt was unfortunate; but, as will be shown in studying the results following the use of the neutral salt, its presence here would, if anything, tend to increase the safety of the spray rather than reduce it. The substance, then, was rather more than half arsenates of lead and rather less than half water.

This material, mixed with water at the rate of 1 part of the dry matter of the paste to 1,000 of water and kept twenty-four hours, gave .03 per cent of arsenic pentoxide (As_2O_5) as entering into solution during that time. As the Federal law permits .75 per cent of solubility under such conditions, it is evident that the sample was of excellent quality from this standpoint.

The rate at which lead arsenate settles when mixed with water is also an important factor, those brands which settle most slowly being distributed most evenly over the tree in spraying. This sample had completely settled eighty-one minutes after a thorough mixing, which is excellent for paste lead arsenates.

Commercial Lead Arsenate Paste. — This material, purchased from a dealer, was of a brand commonly used. Analyzed, it gave: —

	Per Cent.
Water, H_2O	46.32
Water in combination and occlusion	1.26
Lead oxide, PbO	35.44
Arsenic pentoxide, As_2O_5	16.29
Ferric and aluminum oxides	.19
Chlorine, Cl	.31
Nitric acid, HNO_3	trace
Insoluble matter	.04
	99.85

The probable original composition of this paste was substantially as follows: —

	Per Cent.
Water, H_2O	46.32
Water in occlusion	.19
Acid lead arsenate, $PbHAsO_4$	37.96
Neutral lead arsenate, $Pb_3(AsO_4)_2$	13.50
Iron and aluminum as ferric arsenate	.54
Lead chloride, $PbCl_2$	1.22
Nitric acid, HNO_3	trace
Insoluble matter	.04
	99.77

In this material less than 2 per cent could be termed impurities, and these were of such a nature as to make it practically certain they could

not cause any injurious effect on foliage. Rather more than half of the whole consisted of arsenates of lead, but the neutral salt formed a much greater part of the total than was the case with the pure material. About the same amount of water was present as in the pure substance. Or, the total amount of arsenate in the two did not differ greatly, but there was more than three times as much of the neutral arsenate in the commercial salt as in the pure one, the acid arsenate being correspondingly decreased. Any marked difference in the results following spraying by these materials, then, might possibly be explained by this difference in composition. In fact, the results did not differ greatly.

This paste, mixed with water as described for the pure paste, gave .09 per cent of arsenic pentoxide as entering solution in twenty-four hours. This, though more than with the pure paste, is also far below the amount permitted by the Federal law. Complete settling after mixing with water required only thirty-four minutes, showing that this commercial material was rather poor in this regard as compared with the pure paste.

Commercial Acid Lead Arsenate Powder. — The appearance on the market during the progress of these experiments of lead arsenate in powder form led to the addition of this material to the list of substances to be investigated. Samples from a brand on sale were obtained, analyzed and tested like the others. The analysis gave: —

	Per Cent.
Water, H_2O	.45
Water in combination and occluded	3.20
Lead oxide, PbO	63.25
Arsenic pentoxide, As_2O_5	32.22
Ferric and aluminum oxides	.40
Insoluble matter	.38
	99.90

From this the original composition of the powder was probably substantially as follows: —

	Per Cent.
Water, H_2O	.45
Water in combination and occluded	.68
Acid lead arsenate, $PbHAsO_4$	89.93
Neutral lead arsenate, $Pb_3(AsO_4)_2$	7.28
Iron and aluminum as ferric arsenate	1.16
Insoluble matter	.38
	99.88

This material as used for spraying, therefore, contained a little more than 1 per cent of water, about 90 per cent of acid lead arsenate, rather more than 7 per cent of neutral lead arsenate, and about 1½ per cent of impurities, none of them of a nature or present in sufficient amount to be liable to cause any injury.

The amount of arsenic pentoxide which had entered into solution after twenty-four hours of treatment was .16 per cent, which, though more than with either of the other materials already considered, was still far below

that permitted by the Federal law. The time required for the powder to settle was 255+ minutes, which places this sample far ahead of either of the pastes in this regard.

Pure Neutral Lead Arsenate Paste. — This material has been highly recommended as being safer on foliage than the acid lead arsenates, and an investigation of it was therefore also made. To obtain it in a pure or nearly pure form was very difficult, however,[1] and the best sample obtainable analyzed as follows: —

	Per Cent.
Water, H_2O	70.97
Water in combination (calculated)	.08
Lead oxide, PbO	21.10
Arsenic pentoxide, As_2O_5	7.33
Acetic anhydride, $C_4H_6O_3$	.10
Sodium oxide (calculated to combine with last)	.06
Carbonic acid, CO_2	.15
Insoluble matter	.01
	99.80

The original composition of this sample was therefore substantially as follows: —

	Per Cent.
Water, H_2O	70.97
Water occluded	–
Acid lead arsenate, $PbHAsO_4$	3.14
Neutral lead arsenate, $Pb_3(AsO_4)_2$	24.61
Lead carbonate, $PbCO_3$	.91
Sodium acetate, $NaC_2H_3O_2$	.16
Insoluble matter	.01
	99.80

This sample contained a very large amount (71 per cent) of water, was nearly one-quarter neutral lead arsenate, and contained a little over 3 per cent of acid lead arsenate and rather more than 1 per cent of impurities of such a nature as to indicate that it had not been sufficiently washed to remove all the acetic acid, and that impure sodium arsenate containing some carbonate had been used from which to obtain the arsenic. None of these materials was apparently present in sufficient amount to cause any foliage injury, — a view sustained by the results later.

The solubility of the sample in water was .07 per cent on standing twenty-four hours, and it required an hour for complete settling.

None of the materials showed on analysis the presence of impurities of such kinds and in such amounts as to make injury to the foliage from this cause at all probable.

As a commercial neutral lead arsenate could not be obtained which did not contain a large amount of the acid arsenate also, tests of such a material were not made.

[1] See Holland and Reed, *loc. cit.*, p. 203.

Application.

The trees used were the apple, cherry, peach, pear, plum and elm. The materials were applied in the same way in all cases, being thoroughly mixed with the proper amount of water just before using. With the acid pastes, 3 pounds in 50 gallons of water, and with the powder, $1\frac{1}{2}$ pounds, were used, the powder containing approximately twice as much arsenic pentoxide as the pastes. As the neutral arsenate contained much less pentoxide than the acid pastes, 5 pounds 7.6 ounces of it were mixed with 50 gallons of water to provide an amount of arsenic pentoxide in the spray equal to that present in the others. Practically an equal amount of poison was therefore applied in every case.

It has been suggested that injury might be caused by the poison entering the leaf through the stomata. As these are usually more numerous on the lower than on the upper surface, branches were held by the hand in such a position that the spray would reach only one surface of the leaf. Parallel tests for both surfaces were made, one test immediately following the other and on the same tree. The main lines of investigation, though, were with reference to variations of temperature and humidity and of light. Two series were made, one in bright, clear weather, and the other on cloudy days.

The temperature and humidity were obtained from a Hygrodeik manufactured by Andrew J. Lloyd & Co. of Boston, giving both the temperature and relative humidity. These were taken at the tree immediately before applying each spray. The attempt was made to spray each surface of the leaves, both in clear and cloudy weather, for at least every 5° interval between 65° and 95° of temperature, and between 50° and 90° of humidity. To obtain all these combinations, however, proved difficult, and some of them were not obtained until several years had elapsed, though fairly complete series were finally secured.

Application of the sprays was begun in June, continued during July, and a few sprays were put on the trees early in August. The tests were begun in 1912 and ended in 1920. After the spray had been applied, its effect was observed about twice a week for at least two weeks, so that any injury appearing late might not be overlooked.

Adequacy of Experimental Methods.

Three possible sources of error, at least, may have affected this experiment. First, there is the difficulty of a uniform estimation of the amount of injury found. As a check upon this we have the very uniform agreement in observations made at identical and nearly identical temperatures and humidities, not only in the same, but also in different years. The personal equation was reduced as much as possible by having the observations all made by one person. Then, after all, the main dividing line was between injury and no injury, determination of the exact degree of injury being of less importance.

A second source of error was the necessity of using different varieties of the fruit trees, in some cases, in different seasons. If different varieties of the same kind vary in their degree of resistance, the results might be expected to vary also, to some extent. This could not hold for the plum, all tests with this being of the Bradshaw variety, and for the elm, which was always the American elm. With the other trees the results do not indicate, at least, that varietal difference was a factor, though it is generally believed that the Baldwin, for example, burns more easily than the McIntosh. How much the results of these experiments were affected by varietal differences cannot be determined.

The third source of error is the possibility of a difference in the leaves as the season progresses, the later sprays having, perhaps, been applied to leaves which had already begun to "harden." Here, too, the results fail to indicate that this was a factor. Burning occurred as frequently after the late July and early August sprays as following the earlier ones, under similar conditions of temperature and humidity, and it would seem that this possible source of error was of little if any importance.

General Results.

Some general conclusions from the investigation were: —

1. The difference in sensitiveness between the upper and under surfaces of the leaves is so slight as to be negligible. Not more than a dozen cases of difference were observed out of nearly 1,600 applications. In these few the under surface showed the greater injury. Apparently in cases of spray injury, it is not caused by the poison entering the leaf through the stomata.

2. Where insects or fungi had produced holes in the leaves, spray injury was frequently observed around the edges of these holes, while the rest of the leaf was not affected. Whether this injury resulted from a freer access of the poison to the inner leaf cells, or would have resulted in any case, is perhaps uncertain. Such injury was not rated as injury by spraying where the unattacked remainder was not affected.

3. It was frequently the case that injury did not appear until nearly a week after spraying (longer in some cases), and increased in severity later. A branch graded as showing a trace of injury at the end of the first week often increased to "slight" after two or three days, and even to "bad," in a few cases, by the end of the second week. In general, though, the final degree of injury had been reached after about twelve or thirteen days.

4. It is well known that some kinds of foliage are more sensitive to arsenical sprays than others, but details as to this have hitherto been lacking. These tests show that the pear and elm are the most resistant of the trees used in the experiments; that the apple comes next, but is much less resistant; that the cherry comes considerably below the apple in this regard; and that the Bradshaw plum and the peach come some distance below the cherry, and are about equally sensitive, the peach being probably rather the more sensitive of the two.

5. No injury either from the pure or commercial materials was obtained with a combination of the lower temperatures and humidities, but traces of it began to appear as these factors became higher. This indicates that one or both of these affect the leaf in some way so that it becomes more sensitive the higher either one goes, and also that medium high temperatures and medium high humidities act together. The results of this work show that with reasonably good materials injury caused is determined by temperature, humidity and perhaps light. The effects of these are therefore given in greater detail below.

The Effects of Temperature, Humidity and Light.

Pear and Elm. — No case of injury to either of these trees was produced by any of the sprays, even at the highest combinations of temperature and humidity (hereafter written T and H) obtained in the course of the work. It may be remarked, however, that this was not true with Paris green and calcium arsenate, the results with which are not included in this bulletin, both materials seriously injuring the leaves under certain T and H combinations. Combinations as high as T91 H71, T80 H84, and T84 H82 resulted in no injury from lead arsenate, and the conclusion is reached that under any usual combinations of T and H obtainable during the summer months, spraying these trees with any reliable brand of lead arsenate should be entirely safe.

Apple. — Fig. 1 shows the results obtained by using pure acid lead arsenate paste in clear weather. The dots show the T and H points obtained for each test; a circle around the dot indicates that there was no injury; *t* indicates a trace of injury, and *s* indicates slight or "some" injury. Figures in parentheses give the number of tests at the same T and H. A line AB can be drawn across the chart somewhat below the *t* spots, which may be termed the safety line under the conditions of this test. Spraying above the TH limits of this line may not result in injury, as four cases on the chart show, but neither can safety be assured above the line.

Fig. 2 shows the results obtained with the same material applied in cloudy weather. It will be noticed that the lowest humidity was 68°, and that only one high temperature (91°) was met with under the required conditions during the six years the tests were carried on. Apparently, cloudy weather is hardly possible (as is to be expected) with low humidities, and also high temperature tends to dissipate clouds.

So far as can be judged from these tests, there is little real difference in results between clear and cloudy weather, except perhaps at the high humidity end of the safety lines. It would seem that injury begins a little sooner in cloudy than in clear weather at medium T and H, but only slightly so with low T. This is made evident by Fig. 3, where the safety lines only are shown together. Here the cloudy weather line diverges from the other toward the high H end of the diagram, though, after all, only by about 5° at H90.

APPLE — RESULTS OF SPRAYING WITH PURE ACID LEAD ARSENATE.

AB, safety line.

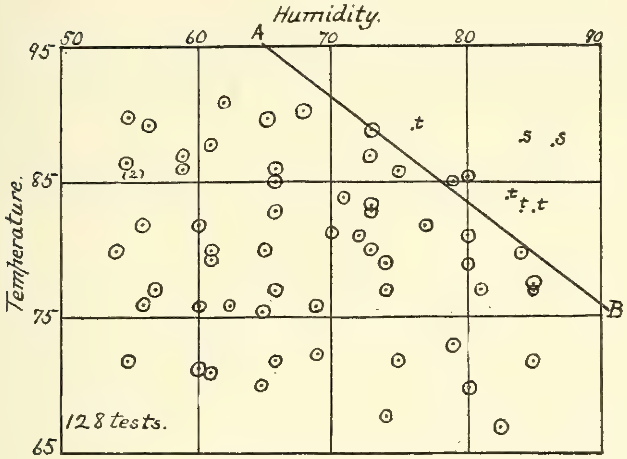

FIG. 1. — Clear weather.

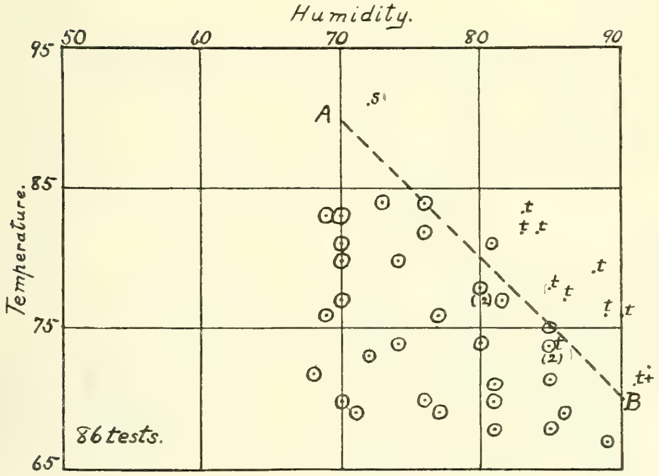

FIG. 2. — Cloudy weather.

With commercial lead arsenate paste the results as shown in Fig. 4 are much the same, though on the whole injury occurs before T and H get quite as high as with the pure paste, particularly at the higher humidities. The clear and cloudy weather lines are more nearly parallel than in the other case.

Apple — Safety Lines for Spraying.

AB, clear weather; CD, cloudy weather.

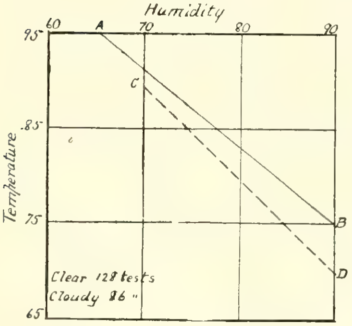

Fig. 3. — Pure acid lead arsenate paste.

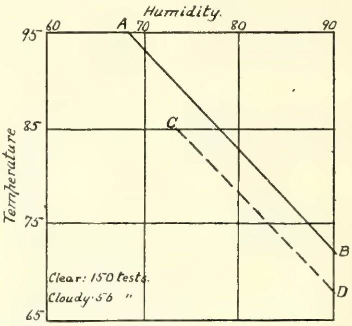

Fig. 4. — Commercial acid lead arsenate paste.

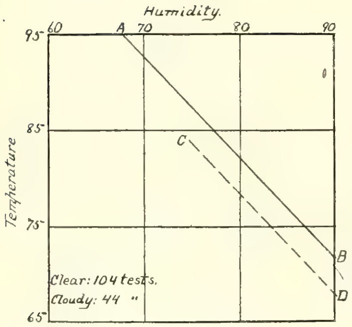

Fig. 5. — Commercial acid lead arsenate powder.

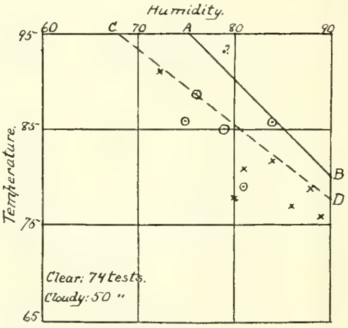

Fig. 6. — Pure neutral lead arsenate paste. Crosses indicate cloudy weather tests with no injury; circles, clear weather tests with no injury.

In the case of commercial lead arsenate powder (Fig. 5), the results differ somewhat, the clear weather safety line beginning at a higher H than in the other cases, but crossing these and running out on H90 at a lower temperature. The total difference, however, is only 4°, so that, after all, there is no great significance in this. The cloudy weather line nearly parallels the clear weather one, and runs about 1° above the commercial paste cloudy weather line.

Results from the use of neutral lead arsenate were rather different from those following the other lead arsenates, this material being apparently the safest of those used. No injury except one doubtful case was found, either

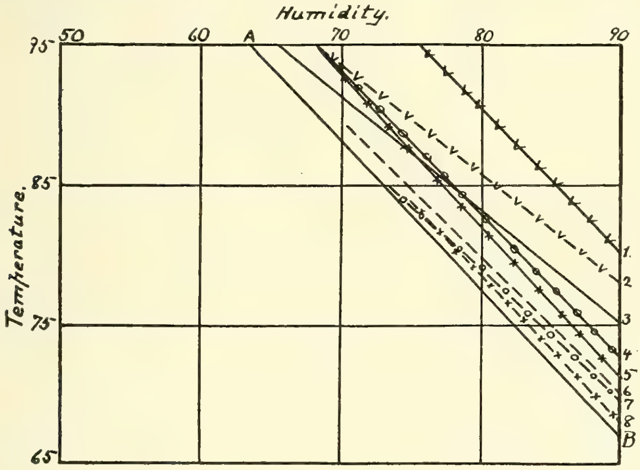

FIG. 7. — APPLE — SAFETY LINES FOR ALL LEAD ARSENATES. AB, safety line for spraying with any reliable lead arsenate under all weather conditions; 1, neutral lead arsenate, clear weather; 2, same, cloudy weather; 3, pure acid paste, clear weather; 4, commercial acid paste, clear weather; 5, commercial acid powder, clear weather; 6, pure acid paste, cloudy weather; 7, commercial acid paste, cloudy weather; 8, commercial acid powder, cloudy weather.

in clear or cloudy weather, at the combinations of T and H obtained, and the safety lines were finally placed near the highest records taken. Fig. 6 shows these records and the placing of the safety line with reference to them. So far as can be judged, then, this material is safe to apply under any ordinary combinations of T and H up to the line AB of Fig. 6.

A general conclusion on the apple is that apple foliage is quite resistant to lead arsenate at high temperatures if the humidity is low, and at high humidities if the temperature is low. Thus, spraying appears to be safe at T90 or higher if the H is below 66. With intermediate T and H, however, the two appear to combine, so that at T82, for example, H should not be above 76.

Cherry. — The cherry appears to be much less resistant to injury than the apple. Fig. 8 gives the safety lines for clear and cloudy weather with pure acid lead arsenate paste. Comparing this figure with Fig. 3, we see that temperature is a more active agent with the cherry than the apple, and that this is even more marked in cloudy weather, though with less difference at low temperatures and high humidity.

CHERRY — SAFETY LINES FOR SPRAYING.

AB, clear weather; CD, cloudy weather.

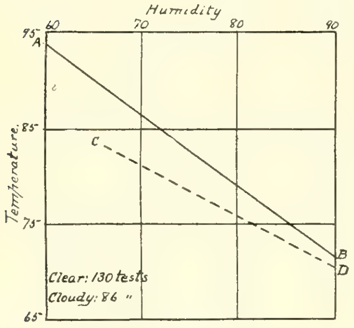

FIG. 8. — Pure acid lead arsenate paste.

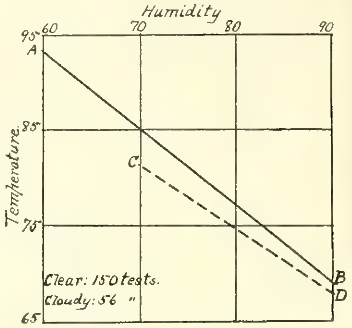

FIG. 9. — Commercial acid lead arsenate paste.

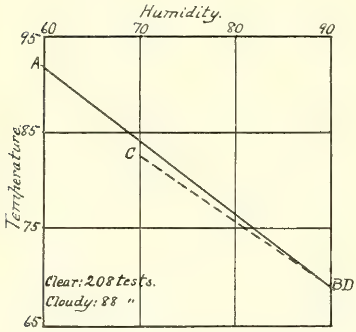

FIG. 10. — Commercial acid lead arsenate powder.

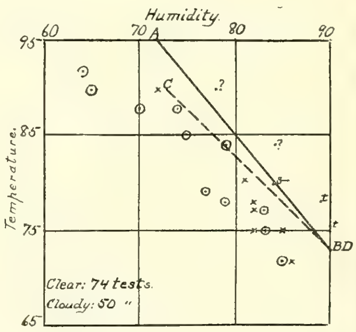

FIG. 11. — Pure neutral lead arsenate paste. Crosses indicate cloudy weather tests with no injury; circles, clear weather tests with no injury.

With commercial acid lead arsenate paste (Fig. 9) the safety lines are very similar to those given in Fig. 8, though a little lower. The difference is insignificant, however. With the commercial acid lead arsenate powder (Fig. 10) the results are also similar, but there seems to be less difference between clear and cloudy weather in producing injury.

The tests with the neutral lead arsenate paste support those on the apple in indicating higher T and H as necessary to cause burning. In Fig. 11 a few of the actual tests are recorded, those marked by circles being clear weather tests and those by crosses, cloudy weather ones. The two interrogation mark tests were clear weather tests, and whether they were really spray injuries is at least doubtful. The two marked "t" and the "s" were cloudy weather tests.

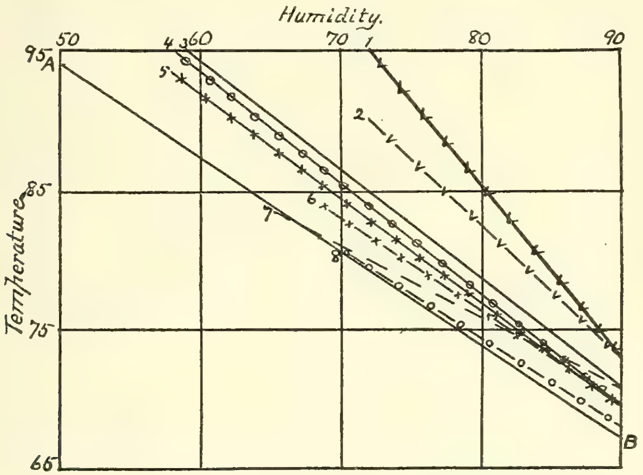

FIG. 12. — CHERRY — SAFETY LINES FOR ALL LEAD ARSENATES. AB, safety line for spraying with any reliable lead arsenate under all weather conditions; 1, neutral lead arsenate, clear weather; 2, same, cloudy weather; 3, pure acid paste, clear weather; 4, commercial acid paste, clear weather; 5, commercial acid powder, clear weather; 6, same, cloudy weather; 7, pure acid paste, cloudy weather; 8, commercial acid paste, cloudy weather.

A combination of all the safety lines is given in Fig. 12. The convergence of the lines, in many cases almost to a common point, produces a rather confusing diagram, the significant features being the detached position of the neutral arsenate (1 and 2), the practical parallelism of the other materials in clear weather, and the fact that these are all located at higher H than the same materials in cloudy weather. The arbitrarily placed line AB may be regarded as the safety line for the cherry with any reliable lead arsenate, either in clear or cloudy weather.

A general study of the results obtained by spraying the cherry indicates that this tree is more sensitive to high temperatures where H is low than the apple, while at high humidity with low T it is, on the whole, more resistant. In both fruits the general agreement in each case of the various acid pastes and the noticeable way in which the neutral arsenate stands apart from the others are very marked.

PLUM — SAFETY LINES FOR SPRAYING.

AB, clear weather; CD, cloudy weather.

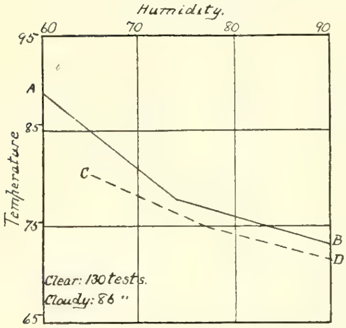

FIG. 13. — Pure acid lead arsenate paste.

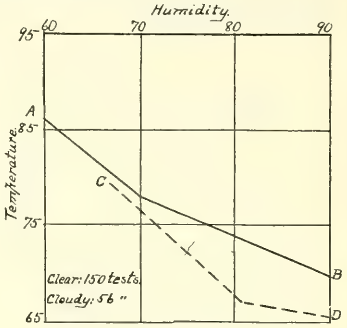

FIG. 14. — Commercial acid lead arsenate paste.

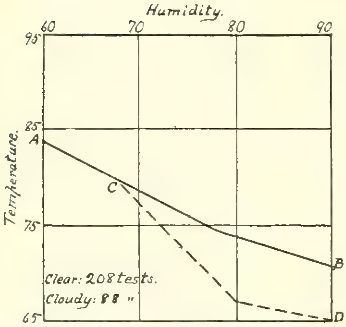

FIG. 15. — Commercial acid lead arsenate powder.

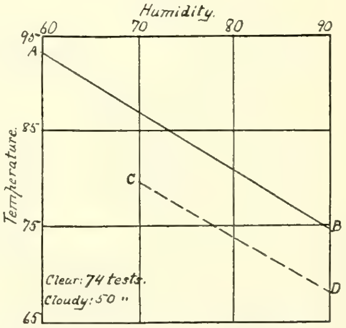

FIG. 16. — Pure neutral lead arsenate paste.

Plum. — The facts obtained here apply only to the Bradshaw plum. The results of the tests of pure acid lead arsenate paste in clear and cloudy weather are given in Fig. 13, and show at once that the resistance of this tree to arsenical sprays is much less than that of the cherry. An addi-

tional feature, here first met with in the work, is the fact that the safety lines are not straight but "elbowed." It would seem from the evidence available that in the case of the plum a combination of medium high T and H becomes dangerous more quickly as these increase than with the cherry or apple. This "elbow" is also shown in Fig. 14 giving the safety lines with the commercial paste. Here the lines run on lower T and H, and in cloudy weather humidities above 80, even with low T, are dangerous. A somewhat similar result following the use of the powder is given in Fig. 15 in the case of cloudy weather. The clear weather results differ only slightly from those with the paste.

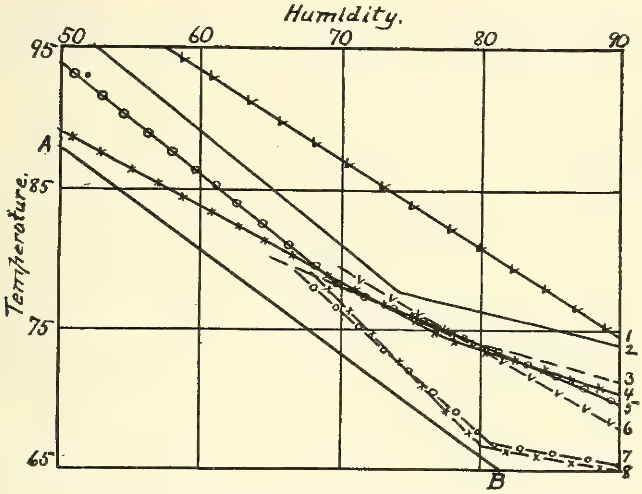

Fig. 17. — Plum — Safety Line for All Lead Arsenates. AB, safety line for spraying with any reliable lead arsenate under all weather conditions; 1, neutral lead arsenate, clear weather; 2, pure acid paste, clear weather; 3, same, cloudy weather; 4, commercial acid powder, clear weather; 5, commercial acid paste, clear weather; 6, neutral lead arsenate, cloudy weather; 7, commercial acid paste, cloudy weather; 8, commercial acid powder, cloudy weather.

The neutral arsenate, as in the case of the other trees, is much safer than the acid arsenates, though the cloudy weather line (Fig. 16) for the first time drops to run about along with those of the acid pastes in clear weather. No "elbow" appears for the neutral arsenate.

In Fig. 17 the various safety lines are brought together on one chart. The striking point shown here is that in the high humidities of cloudy weather the commercial paste and powder, closely following each other, drop far below the other lines. On the whole, the line AB should mark a safety line, however, at or below which spraying on the plum should be safe under any combinations of T and H with any reliable material.

General conclusions as to the plum, so far as the evidence goes, are: first, that this tree is far less resistant to arsenicals under certain conditions of T and H than the cherry; second, that in clear weather it is less sensitive to high humidities than to high temperatures when the other factor is low; third, that this last does not hold for the acid paste and powder in cloudy weather; and fourth, that again the neutral lead arsenate is the safest of the materials used.

PEACH — SAFETY LINES FOR SPRAYING.

AB, clear weather; CD, cloudy weather.

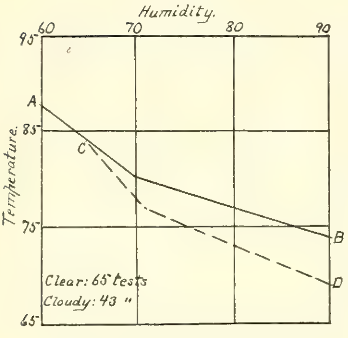

FIG. 18. — Pure acid lead arsenate paste.

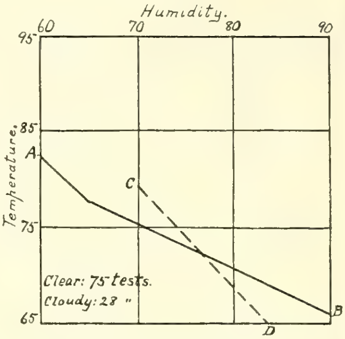

FIG. 19. — Commercial acid lead arsenate paste.

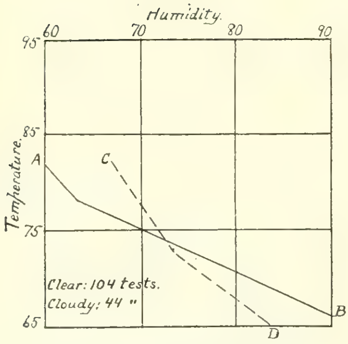

FIG. 20. — Commercial acid lead arsenate powder.

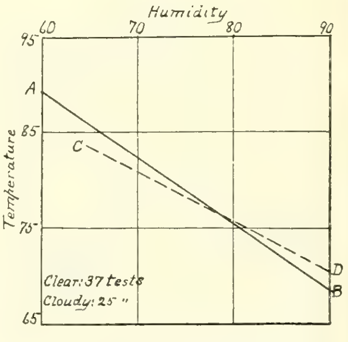

FIG. 21. — Pure neutral lead arsenate paste.

Peach. — The results of the experiments on the peach are, on the whole, very similar to those obtained from the plum. In general, the safety lines are very close, and the conclusion reached that the plum is somewhat more resistant than the peach is based mainly upon experiments with other arsenicals. There seems to be less difference at the T and H limits of the charts than was shown for the plum. In three sets of tests (Figs. 19, 20 and 21) the clear and cloudy weather lines cross, but the difference is not very great. The neutral arsenate fails to make quite as good a showing as with

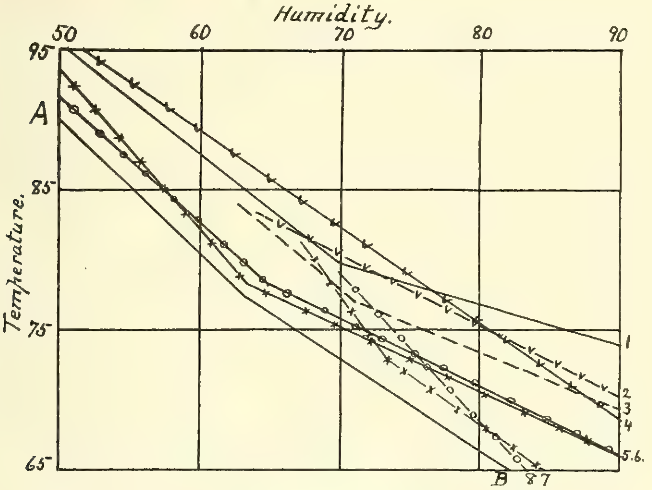

Fig. 22. — Peach — Safety Lines for All Lead Arsenates. AB, safety line for spraying with any reliable lead arsenate under all weather conditions; 1, pure acid paste, clear weather; 2, neutral lead arsenate, cloudy weather; 3, pure acid paste, cloudy weather; 4, neutral lead arsenate, clear weather; 5, commercial acid paste, clear weather; 6, commercial acid powder, clear weather; 7, same, cloudy weather; 8, commercial acid paste, cloudy weather.

the other trees, but is, nevertheless, still the best for the greater part of its range. "Elbowing" of the safety lines is again in evidence except with the neutral arsenate and the commercial acid paste in cloudy weather. Perhaps in this last case a larger number of tests (it was not possible to make very many) might change the path of this line somewhat. Comparison of Figs. 17 and 22 shows that the peach appears to resist injury slightly better than the plum at high T and low H, while at high H and low T the two are about alike.

It should be noted that in Figs. 7, 12, 17, 22 and 23 the chart is extended 10° lower in humidity than the others to show the paths of the safety lines in this added area. To make comparisons with the others, reading of these charts should begin, not at H50, but at H60.

In order to obtain some idea of the relative resistance of the apple, cherry, plum and peach to arsenical sprays, Fig. 23 has been prepared, the material used in each case being the pure acid lead arsenate paste applied in clear weather. The elm and pear are not included, for as already stated, no injury points were obtained. If their safety lines come into the chart at all, they would only cross the upper right square, and probably would not occur unless close to H90 T95.

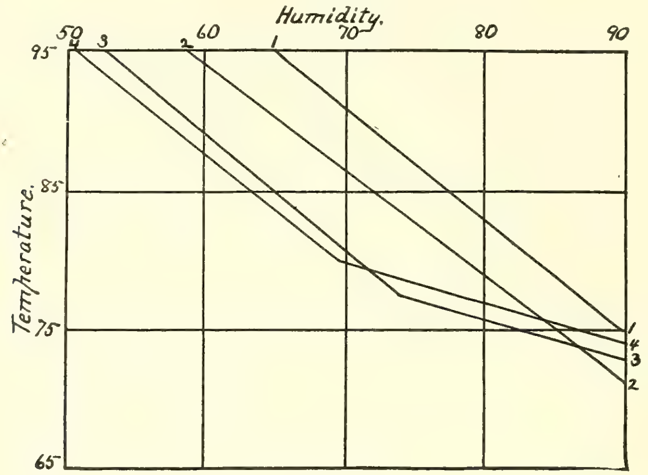

FIG. 23. — Safety lines for spraying with pure acid lead arsenate in clear weather: 1, apple; 2, cherry; 3, plum; 4, peach.

GENERAL CONCLUSIONS.

An analysis of the effects of temperature, humidity and light given in detail above brings out several features of interest: —

1. The neutral lead arsenate used, even though it was not entirely pure, proved the safest of the materials in clear weather, and in most cases was better even in cloudy weather than the others.

2. The clear weather spraying is safer than the cloudy weather, though the difference generally is not great.

3. The indication is that spraying at high temperatures can be done safely if the humidity is low.

4. Spraying can be carried out safely at high humidities if the temperature is low, though the humidity cannot run up as high as the temperature can at the other end of the line. Thus spraying the apple seems to be safe at T90 when H is not over 69, but is not safe at H90 when T is above 67.

5. Between the ends of the safety lines of the charts, *i.e.*, with medium T and H, both seem to have an influence.

6. With the apple and cherry the safety lines are straight, while in the plum and peach most of them "elbow," indicating that the T and H fac-

tors are more powerful at medium values, or when both act in medium amounts, than where either one is low, even though the other be high.

7. In the case of the plum the elbow is between H70 and H80, while with the peach it tends to move back toward lower humidities; or, in other words, the plum seems to be more sensitive to higher humidities than the peach, and also at the extremes of the safety lines to both T and H.

8. From the tests with lead arsenate, the peach and the Bradshaw plum at least appear to have about the same degree of resistance to arsenical sprays.

From the evidence at hand it would seem that, with reliable arsenicals properly made, mixed and applied, injury results from the combination of temperature, humidity and light factors. A high value for either of the first two factors, provided the other is low, indicates probable safety, particularly on sunny days.

Why divergence from these requirements should cause burning has not been brought out by this work. It may be that, as the injury generally appeared only after a week or more, there was some chemical factor at work. With some carbonic acid in the air and heavy dews at night it might be possible that a slow decomposition of the arsenate on the leaves took place, gradually liberating the arsenic and resulting after a time in injury. If this were correct, however, it would seem as though the decomposition of the arsenate would take place when sprays were applied at T and H combinations below the safety line, and cause burning in those cases also. Possibly the leaf differs in its physiological activities under different conditions of light, temperature and humidity, and under some of these is susceptible to influences not effective under others.

The most that can now be said is that this work has failed to answer the question why arsenical sprays sometimes injure foliage, though it has shown that of the four explanations given at the beginning, the first, second and fourth can be rejected, and that the problem is apparently one for the plant physiologist, the chemist, or both working together, to solve. The demonstration of safety limits for spraying can hold good, however, even though the question of why they are located where they are remains unanswered.

BULLETIN No. 208.

DEPARTMENT OF POMOLOGY.

LEAF CHARACTERS OF APPLE VARIETIES.

BY J. K. SHAW.

It is as easy to recognize varieties of apples by their tree characters as by their fruit, yet all fruit growers know varieties by the fruits much better than by the trees. This is doubtless because they come into closer contact with the fruit. They pick, handle and eat the fruit, while contact with the trees is less frequent and intimate. Nurserymen are more familiar with the tree, and many old nurserymen know varieties by the nursery trees better than by the fruit. As trees have been studied less than the fruit, there has been less written about them. Variety descriptions deal mostly with the fruit. John J. Thomas, himself a nurseryman of many years' experience, discussed tree characters at some length in his "American Fruit Culturist," but his work along this line has been given little attention by other writers.

In recognizing varieties, especially with nursery trees, one depends largely on the leaves, and it is our purpose here to discuss the leaf characters by which we may know one variety from another. Characters of the bark, buds, branches and general habit of the trees are very useful, perhaps equal to the leaves, but they will receive only incidental mention here, being reserved for further study and later discussion.

In order to talk understandingly about the leaves we must have names for their different parts. These are shown in Fig. 1, which is largely self-explanatory. The leaf is first divided into three parts: stipules, petiole and blade. About one-third of the blade next to the petiole is called the base, and similarly about one-third of the other end, the apex; beyond this is the narrow point called the tip. The midrib is a continuation of the petiole to the tip of the leaf. The saw-like notches along the edge of the leaf are called serratures or serrations, and are of the greatest importance, being rarely exactly alike in two varieties.

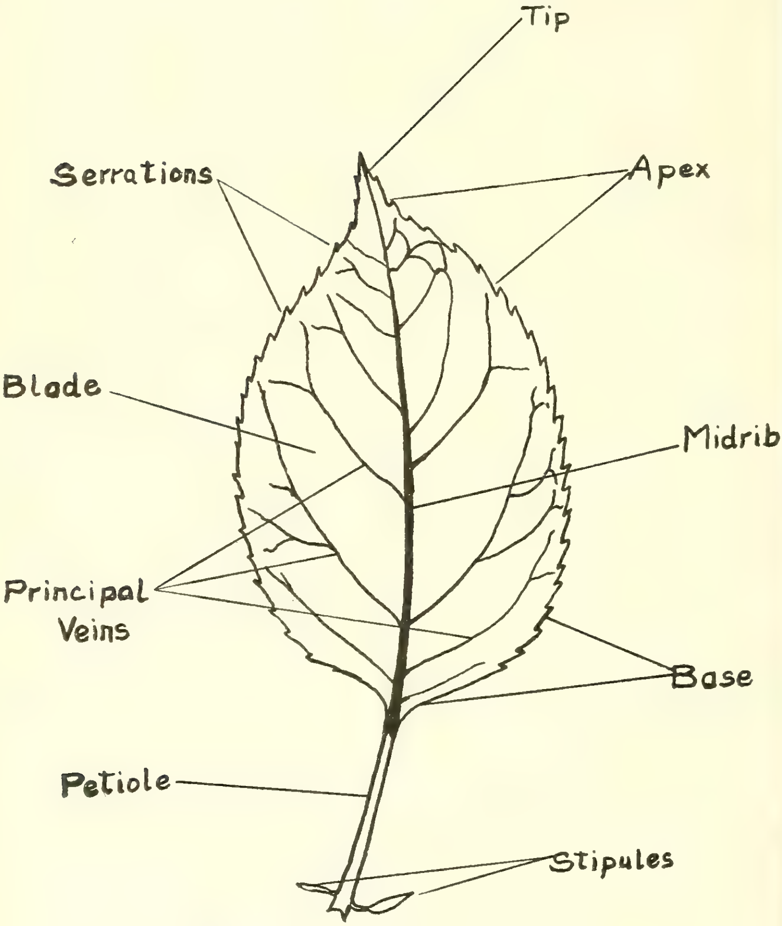

FIG. 1.—Diagram of apple leaf, showing parts.

Which are the Characteristic Leaves.

The leaves on any tree can be divided into two groups: (1) the single leaves coming out on the current season's growth; and (2) the rosette leaves coming out of buds formed the previous season, *i.e.*, on wood of last year's growth. *The latter should be discarded, and study and attention centered on the single leaves on the current season's growth.* Leaves that have been injured by lice or other insects or by scab spots are of little value for identification purposes. Leaves on shoots in the interior of the tree should be avoided. *Study the well-developed uninjured leaves usually found along the middle of the season's growth.* Leaves on trees that are poorly nourished are often undersized and yellowish. Such leaves are not typical and should be observed with caution.

Typical leaves are found on healthy uninjured trees that are making vigorous but not excessive growth. Inasmuch as one requires the leaves of the current season's growth, little progress can be made in leaf study until considerable growth has been made. The most favorable period is from July 1 until October 1. To one familiar with leaf characters this period may be extended somewhat.

What to Look at.

To the beginner in leaf study the leaves of all varieties will look alike. Close and repeated observation will reveal differences that are peculiar to the different varieties. It is our purpose here to discuss the various parts of the leaf and how they differ in different varieties. (See Fig. 1.)

The Petiole.

The petiole or stem of the leaf is sometimes characteristic of the variety, though it is of minor importance. Wealthy has a rather long, slender petiole, while that of McIntosh is usually short and stout. The angle which the petiole forms with the shoot on which it grows is often helpful in recognizing varieties. In the Spy the angle is sharp, that is, the leaf is said to be upright; while in the Rhode Island Greening it is broad or spreading. This character is correlated in all varieties with the form of the top. The Spy has an upright head, while the Rhode Island Greening is distinctly spreading. This character of the head or form of the tree is quite well known to fruit growers, but few are aware that in an unknown variety the form of the top can be foretold with considerable accuracy from the leaf angles on a one-year whip.

The Stipules.

The stipules located at the base of the petiole have a certain value in variety identification. They vary in size and shape and in the degree to which they persist. In all or nearly all varieties they are likely to fall by late summer or early fall, especially if there is a good deal of dry weather.

The Blade.

Size. — Coming now to the blade we find the most dependable characters for variety identification. Let us first consider the size of the leaf blade. This, of course, varies considerably with the vigor of the tree. Trees in a sod orchard making little growth will have much smaller leaves than will the same variety growing under cultivation and making a vigorous growth. Leaves well exposed to the sun will be smaller than those growing in shade, as in the interior of the tree. With these reservations in mind, we may say the Jonathan (Fig. 17) has a small leaf, while Rhode Island Greening (Fig. 4) and King (Fig. 24) have large leaves; Wealthy (Fig. 7) is a little smaller than Baldwin (Fig. 8); and McIntosh (Fig. 3) a little larger than Wolf River (Fig. 12).

Shape. — Next we may consider the shape or outline of the leaf. This may vary in different varieties in two ways: in relative length and width, and in the width of the base and apex. Winter Banana (Fig. 10) is relatively long and narrow, while Baldwin (Fig. 8) is relatively short and broad. An example of the second is found in comparing Wolf River (Fig. 12), which is narrow at the base and apex, with McIntosh (Fig. 3), which is broad at the base and apex. This difference is especially valuable in distinguishing between Oldenburg (Fig. 6) and Wealthy (Fig. 7), the former being much broader at the base and apex than the latter.

Tip. — The narrow tip called the point is of some value, being larger and more slender in some varieties, usually those with a narrow apex, than in others.

Folding. — Next we may consider the various types of bending and folding which may appear in the leaf blade. The blade may be flat as in Gravenstein (Fig. 2) and Wealthy (Fig. 7), or it may be folded to a greater or less degree as in Baldwin (Fig. 8) or Wagener (Fig. 15). The last two varieties exhibit different types of folding, it being broad, saucer-shaped or boat-shaped in the Baldwin, and much narrower and more pronounced in the Wagener. Leaves of a given variety may show this character in varying degree according to condition; the folding is more pronounced in periods of dry, sunny weather than it is during cloudy or rainy periods. Jonathan, as shown in Fig. 17, shows only moderate folding, but at times it may show very pronounced folding, — sometimes more than any variety illustrated here. Nevertheless, it is a most valuable character in the identification of varieties. The peculiar saucer-shaped folding of the Baldwin is always seen in greater or less degree in a considerable proportion of the single leaves on the tree, and with one or two other peculiarities will serve to distinguish this variety from all others.

Next we may consider the bending or waving of the leaf edge. Flat leaves do not often show this, although it appears quite noticeably in Oldenburg and Wealthy, neither of which are folded very much. Some folded leaves are very distinctly waved, as Wagener (Fig. 15), Hubbardston (Fig. 22) and Tolman (Fig. 27), while others show it but little, as Baldwin (Fig. 8), Roxbury Russet (Fig. 9) and Winter Banana (Fig. 10).

A third type of bending or folding of the leaf blade is seen in the bending backward or reflexion of the midrib. Pronounced reflexion of the midrib is not common in flat leaves, but is the usual thing in strongly folded leaves if the folding is of the narrow type. Thus Baldwin (Fig. 8) and Roxbury Russet (Fig. 9) are not reflexed, while Grimes (Fig. 20) and Wagener (Fig. 15) are strongly reflexed.

Serratures. — Probably the most dependable leaf character for identifying varieties is the nature of the serratures along the edge of the leaf. They are sharp in Rhode Island Greening (Fig. 4) and dull in Wolf River (Fig. 12) and Wealthy (Fig. 7). Other varieties are intermediate between these extremes, but every variety is peculiar to itself and different from other varieties. In Rhode Island Greening (Fig. 4) the serratures are distinct or well separated, while in Gravenstein (Fig. 2) and Baldwin (Fig. 8) they are set close together or indistinct. They vary in depth also, and in some varieties they are straight, as in Rhode Island Greening, while in Baldwin they are more or less curved or sickle-shaped. The last peculiarity, together with the saucer-shaped folding referred to above, serves to distinguish Baldwin from all other varieties known to the writer. If one leaf is laid upon another so that the serratures of both can be seen and carefully compared, the observer with some experience can very often tell quite positively whether the leaves represent one variety or two varieties.

Texture. — The veins of the leaves divide and subdivide until they form a network all over the surface of the leaves. This network is coarser in some varieties than in others. There are other peculiarities in the veining hard to describe in words, but evident and distinct in the leaves. These peculiarities taken together are spoken of as texture. The texture of Rhode Island Greening (Fig. 4) is very different from that of McIntosh (Fig. 3). Comparisons of other varieties will show differences in texture difficult to picture in words, but of much value in recognizing varieties.

Pubescence. — All varieties have more or less growth of short hairs over the under surface. Those having an abundant growth of these hairs are said to be pubescent or "woolly." This is not shown very clearly in the figures, but may be seen by observing the leaves themselves. Ben Davis and Jonathan are examples of "woolly" leaves, while Rhode Island Greening shows very little of this growth. This hairy growth is sparse on Baldwin and more abundant on Hubbardston and McIntosh.

In some varieties the surface of the leaves is smooth and shining, while at the other extreme are some varieties that appear rough or dull. This is correlated with hairiness or woolliness of the surface, the smooth and shining leaves having few hairs, while the rough or dull ones have many.

Thickness. — Varieties differ also in the thickness of the leaves. McIntosh and Wealthy have relatively thick, stiff, rigid leaves, while those of Rhode Island Greening, Grimes and Fall Pippin seem thinner and less rigid to the touch.

Color. — All apple leaves are, of course, a deep rich green in color. The shade of green depends a good deal on the vigor of the trees, being deeper in vigorous trees, and a paler, more yellowish green in trees making little

growth. There are also varietal differences in color. In Rhode Island Greening and in all green-fruited varieties the color is a rich, clear green; in varieties that have much red in the color of the fruit the leaves are a deeper green with a slight bluish or purplish cast. This is seen in McIntosh. Yellow Transparent has leaves of a yellowish green cast. These differences in leaf color are not pronounced, and as stated above vary with the condition of the trees, but they are very helpful in recognizing varieties.

In distinguishing two or more varieties which are mixed in the nursery row, one may often find some peculiarity of a certain variety present at the particular time at which the observation is made, which serves to distinguish that variety with ease and certainty. For example, in separating out Wolf River trees in a mixture with McIntosh it was observed that, at the time the Wolf River leaves were beginning to turn yellow and perhaps one-third of them had fallen, the McIntosh leaves showed very little yellowing and few if any had fallen. By observing this difference it was possible to separate the two varieties with the greatest ease and certainty. Yet at an earlier period this difference would not have been present. In the late summer the Yellow Transparent leaves near the tips of the shoots frequently show a spiral folding that displays plainly the under side of a portion of the leaf. When this peculiarity is shown it is possible to recognize a Yellow Transparent tree as far as it can be seen. It is the usual thing in separating mixed varieties to fix on some one character by which the varieties can, at that particular time and place, be positively distinguished one from the other.

Classification of Varieties.

Twenty-six varieties of more or less importance in Massachusetts have been selected for illustration and description in this bulletin. The following key is arranged to show, as well as possible, the differences by which these varieties may be distinguished. It is not thought that this key will enable one to trace out unknown varieties, but it may help in orchard and nursery studies of the leaves of these varieties. A few tree characters are mentioned with the hope that they may be helpful.

A. Varieties important in Massachusetts.
- 1. Leaves large, broad, flat or only slightly folded.
  - (*a*) Sides not waved or only very slightly so.
    - *Gravenstein.* — Leaves broad oblong; serrations dull, shallow, regular; branches broadly ascending; bark dark yellowish. (Fig. 2.)
    - *McIntosh.* — Leaves broad oval, base often cordate, edges often slightly folded; serrations dull and shallow, especially at base. (Fig. 3.)
    - *Rhode Island Greening.* — Serrations very sharp and distinct. (Fig. 4.)
  - (*b*) Sides more or less waved.
    - *Red Astrachan.* — Leaf waves "crinkly" or wrinkled, not reaching to midrib. (Fig. 5.)
    - *Oldenburg.* — Leaves broad at base and apex; shoots few and stout. (Fig. 6.)
    - *Wealthy.* — Leaf relatively narrow at base and apex; midrib often tending to spiral form or reflexed at tip. (Fig. 7.)

A. Varieties important in Massachusetts — *Concluded.*

2. Leaves more or less distinctly folded.

(*a*) Folding "saucer-shaped" or broad U-shaped.

Baldwin. — Leaves broad, distinctly saucer-shaped; serrations sharp, close set and usually curved. (Fig. 8.)

Roxbury Russet. — Serrations distinct and only moderately sharp; bark olive green. (Fig. 9.)

Winter Banana. — Leaves rather long and narrow; serrations regular and dull; branches long and slender, yellowish. (Fig. 10.)

(*b*) Folding narrow U-shaped.

(1) Serrations dull.

Williams. — Waves large, coarse; serrations uniform; growth open; bark yellowish. (Fig. 11.)

Wolf River. — Leaf only moderately folded, oval, narrowing at base and apex; serrations coarse, dull. (Fig. 12.)

Yellow Transparent. — Leaves broad at base and rather narrow at apex; serrations uniform, shallow. (Fig. 13.)

(2) Serrations at least moderately sharp.

Delicious. — Leaves narrow at apex; serrations coarse and distinct. (Fig. 14.)

Wagener. — Leaves strongly folded; midrib much reflexed; shoots stout with large buds. (Fig. 15.)

Northern Spy. — Leaves sometimes little folded, upright; serrations sharp; shoots upright; bark russet with many small dots. (Fig. 16.)

B. Varieties of minor importance in Massachusetts.

1. Leaves usually only slightly folded, serrations rarely sharp.

(*a*) Leaves small, coarsely and irregularly serrate.

Jonathan. — Leaves very small, narrow at base and apex, sometimes folded; tree slender, of open habit. (Fig. 17.)

King David. — Leaves narrow at base but wider at apex; tree strong and vigorous. (Fig. 18.)

Stayman. — Leaves nearly round, spur leaves and some shoot leaves sharply serrate; tree vigorous. (Fig. 19.)

(*b*) Leaves medium-sized, serrations rather fine and regular.

Opalescent. — Leaves sometimes slightly waved, rather narrow at apex; bark of shoots very smooth. (Fig. 20.)

2. Leaves distinctly folded and waved.

(*a*) Serrations distinct and rather sharp.

Fall Pippin. — Leaves long, sharply and distinctly serrate; tree vigorous. (Fig. 21.)

Hubbardston. — Serrations moderately sharp; midrib reflexed; bark olive green. (Fig. 22.)

Grimes. — Serrations sharp and distinct; midrib reflexed. (Fig. 23.)

Tompkins King. — Tree vigorous with long stout shoots, does not branch freely. (Fig. 24.)

(*b*) Serrations not sharp but rather dull.

Ben Davis. — Leaves rather narrow, grayish and woolly. (Fig. 25.)

Esopus Spitzenburg. — Serrations dull and regular; midrib usually only slightly reflexed. (Fig. 26.)

Tolman. — Leaves narrow at base and strongly waved; serrations only moderately dull. (Fig. 27.)

The varieties in the foregoing classification are illustrated in the following pages. These cuts are approximately two-thirds life size. While, as stated in the text, the size of the leaves may vary with cultural conditions, yet these may be taken as fairly representative, and are comparable one with another.

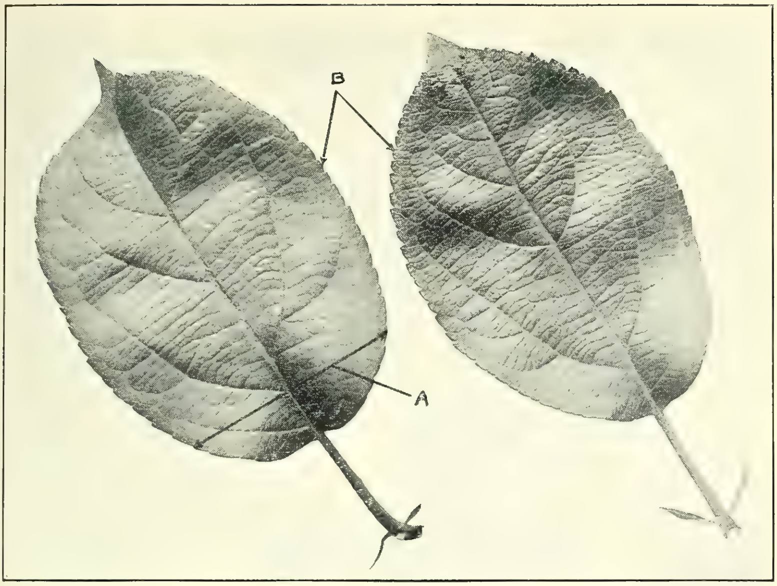

Photo by R. L. Coffin.

FIG. 2. — GRAVENSTEIN. Blade large, flat, rounded or rather narrow at base (A); serrations moderately sharp and shallow (B), fairly regular.

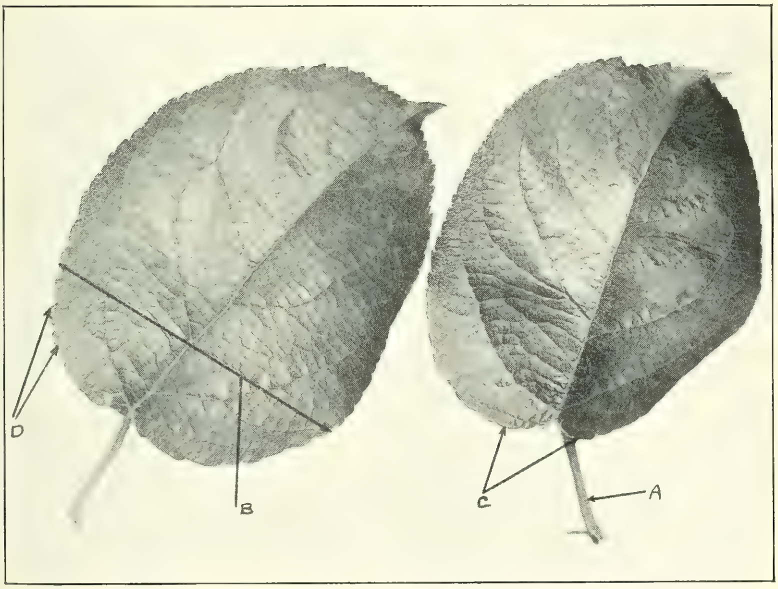

FIG. 3. — McINTOSH. Petiole short (A); blade large, flat or slightly folded near edge, broad (B) and heart shaped (C) at base, deep bluish green; serrations rather dull and shallow, especially at base (D).

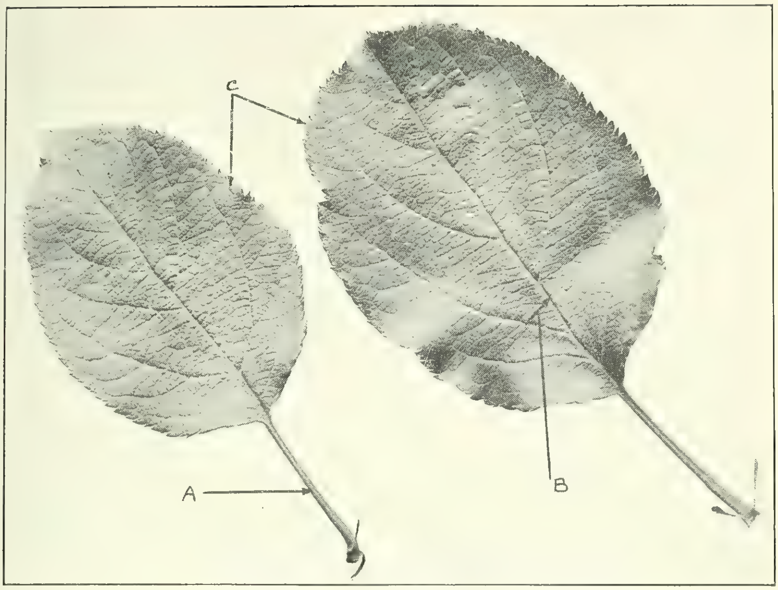

Photo by R. L. Coffin.

FIG. 4. — RHODE ISLAND GREENING. Petiole long (A); blade large, flat, deep clear green; vein angle sharp (B); serrations very sharp, deep and distinct (C).

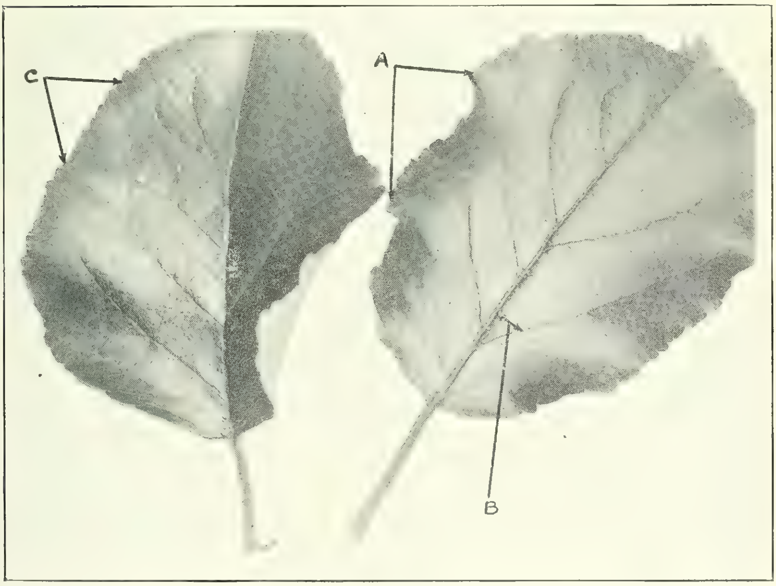

FIG. 5. — RED ASTRACHAN. Blade large, broad, flat, with waved and wrinkled edges (A); vein angle sharp (B); serrations dull and irregular (C).

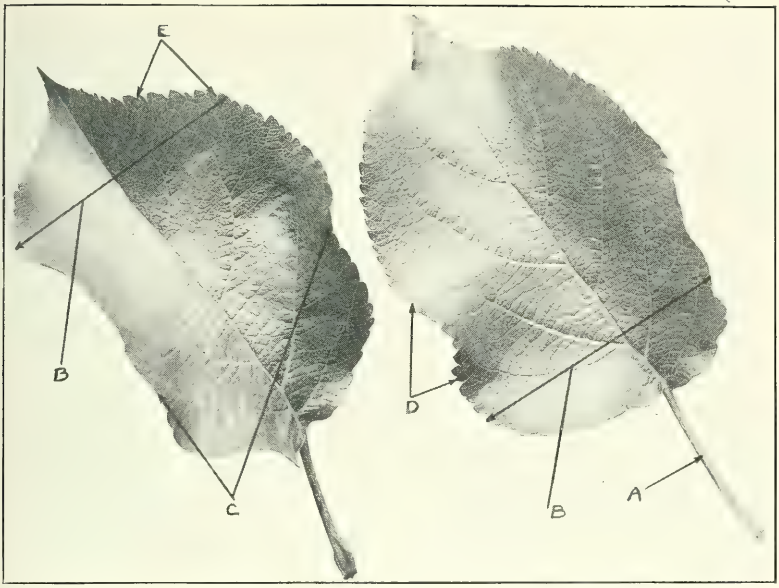

Photo by R. L. Coffin.

FIG. 6. — OLDENBURG. Petiole long (A); blade above medium to large, broad at base and apex (B), somewhat folded (C), and waved (D); serrations moderately sharp and irregular (E).

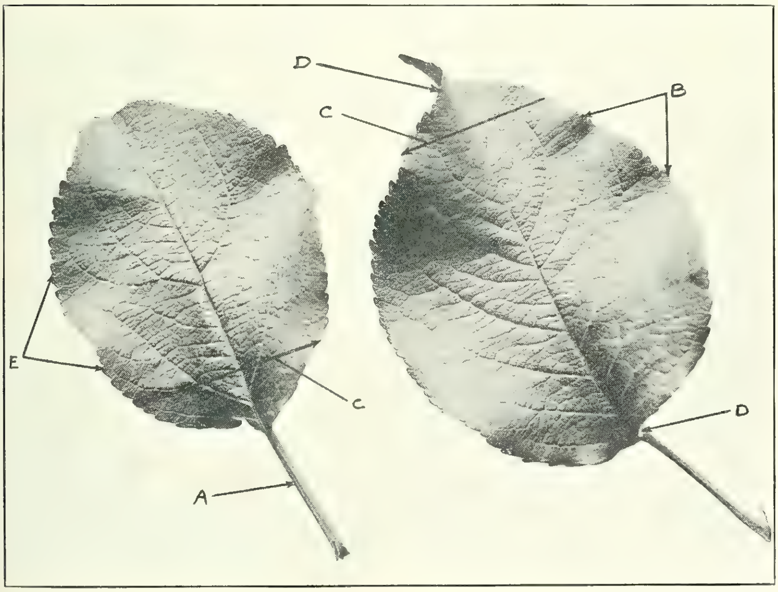

Photo by R. L. Coffin.

FIG. 7. — WEALTHY. Petiole long (A); blade moderately large, flat, with waved edges (B), narrow at base and apex (C); midrib reflexed or spiral (D); serrations rather dull (E).

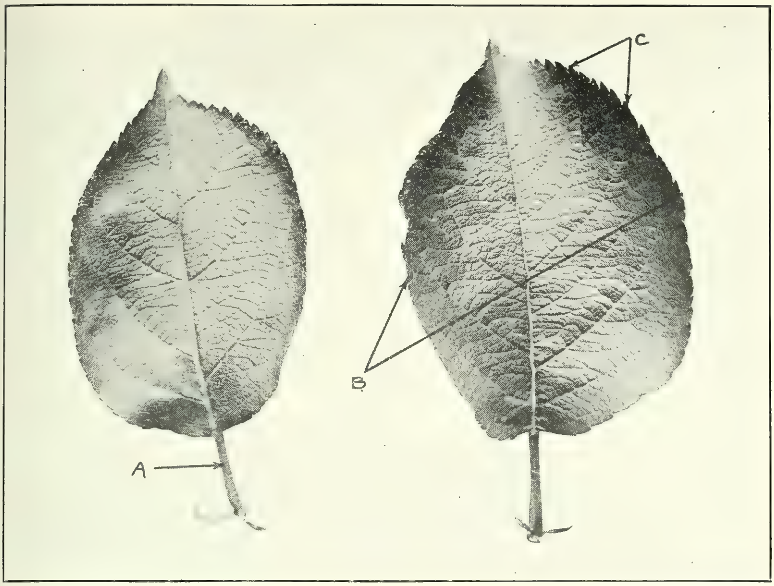

Photo by R. L. Coffin.

FIG. 8. — BALDWIN. Petiole short (A); blade large, broad, with "saucer shaped" folding (B); serrations sharp, close set, usually curved (C).

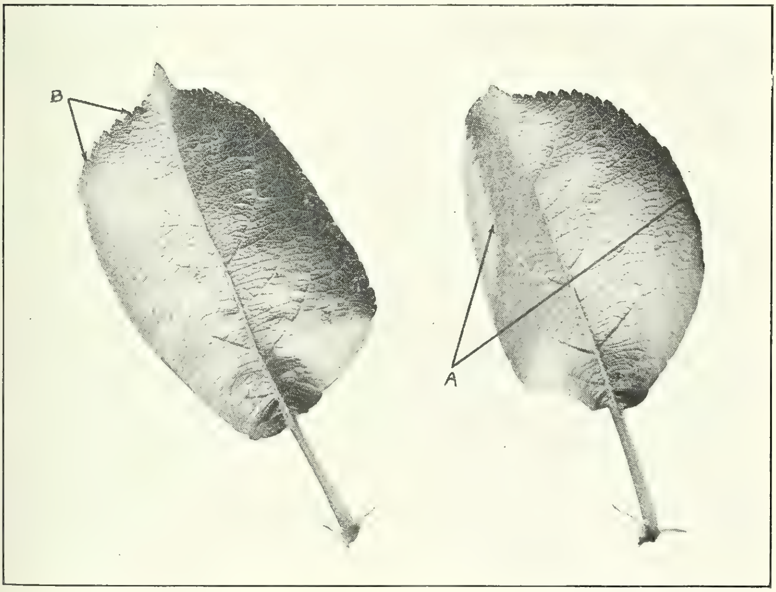

Photo by R. L. Coffin.

FIG. 9. — ROXBURY RUSSET. Blade large, broad, with "saucer shaped" folding (A); serrations not sharp nor curved (B).

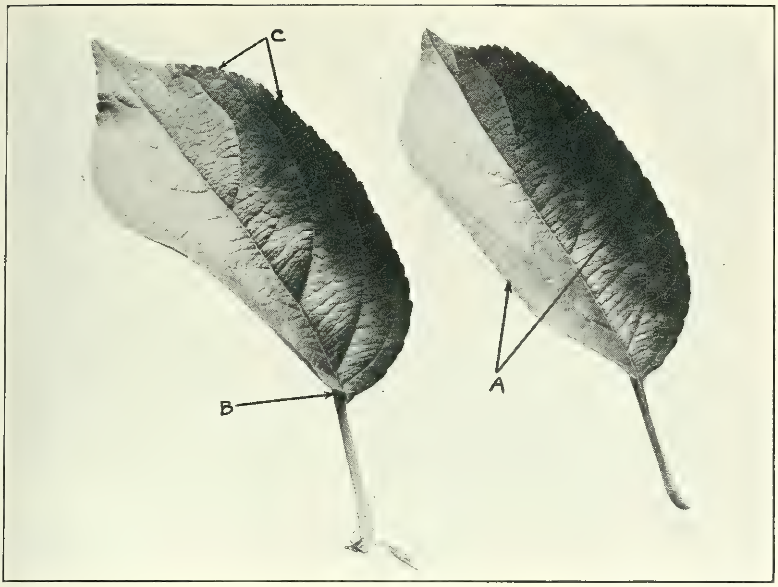

Photo by R. L. Coffin.

FIG. 10. — WINTER BANANA. Blade medium size, rather long and narrow, folded (A); midrib bent at base (B); serrations rather dull and shallow (C).

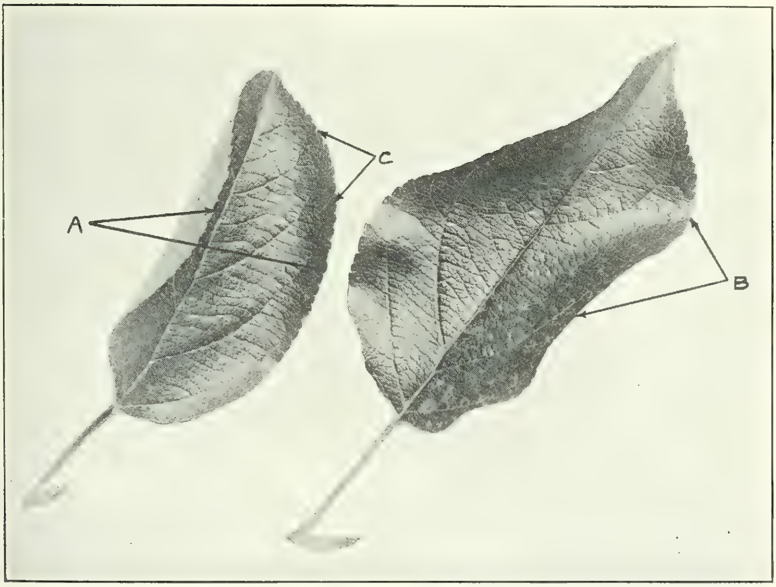

FIG. 11. — WILLIAMS. Blade medium size, folded (A) and often coarsely waved (B); serrations rather dull and quite regular (C).

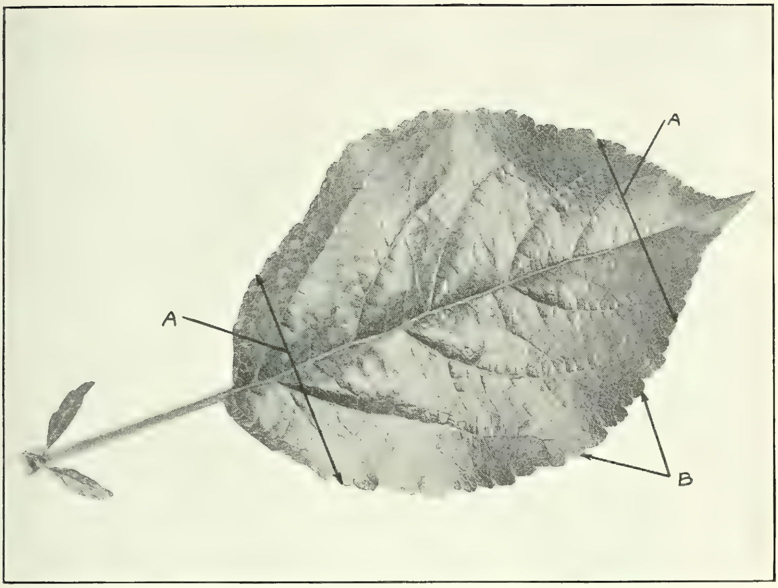

Fig. 12. — Wolf River. Petiole long; blade often only slightly folded, narrow at base and apex (A); serrations coarse and dull, often double (B).

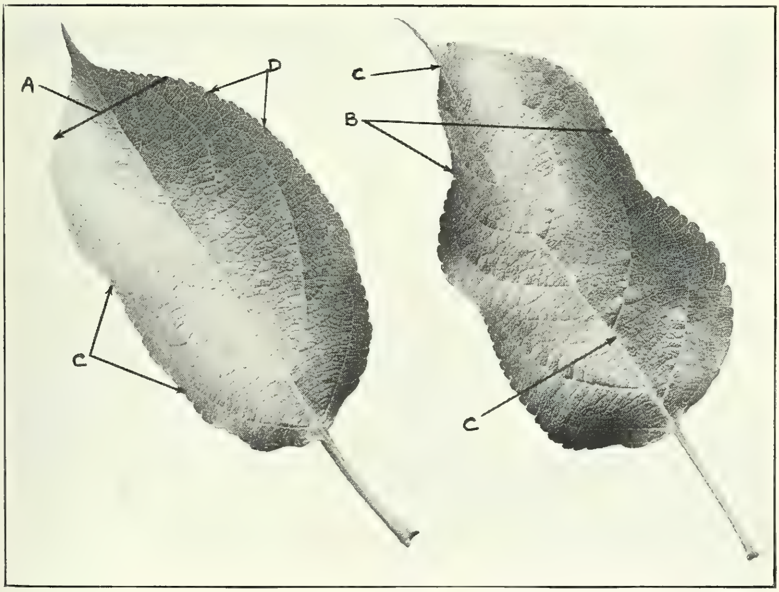

Photo by R. L. Coffin.

Fig. 13. — Yellow Transparent. Blade medium size, rather broad at base and narrow at apex (A), more or less folded (B), more or less waved, and often spiral (C); serrations rather dull, shallow and quite regular (D).

FIG. 14. — DELICIOUS. Blade medium size, apex narrowing to point (A), partly folded (B); serrations moderately sharp, coarse and rather irregular (C).

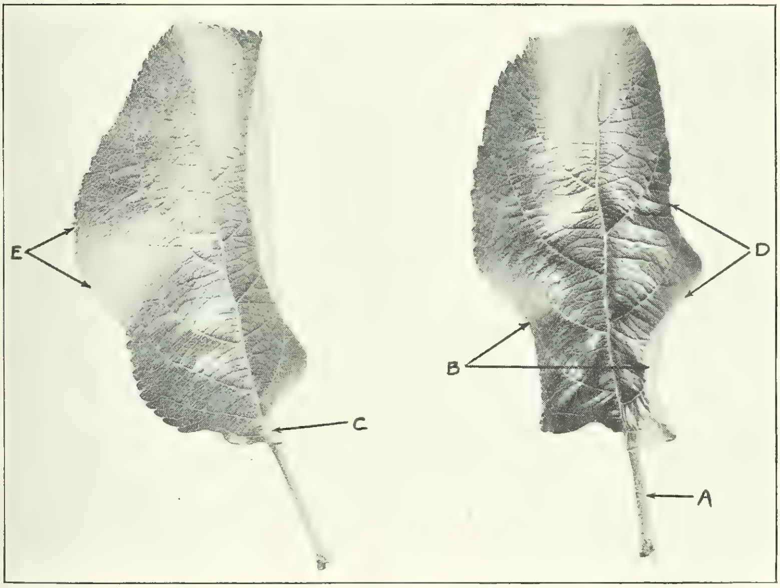

Photo by R. L. Coffin.

FIG. 15. — WAGENER. Petiole short and stout (A); blade large, long and rather narrow, strongly folded (B), reflexed (C), and waved (D); serrations rather sharp, coarse and distinct (E).

Photo by R. L. Coffin.

FIG. 16. — NORTHERN SPY. Blade large, somewhat folded and waved, upright, often somewhat reflexed; serrations sharp, often curved (A).

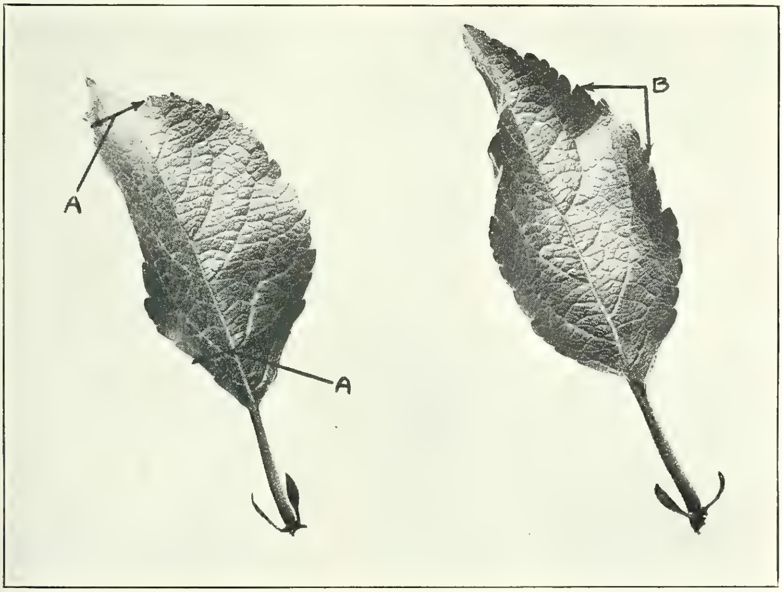

Photo by R. L. Coffin.

FIG. 17. — JONATHAN. Blade very small, more or less folded, sometimes reflexed, narrow at base and apex (A); serrations moderately sharp, coarse and irregular (B).

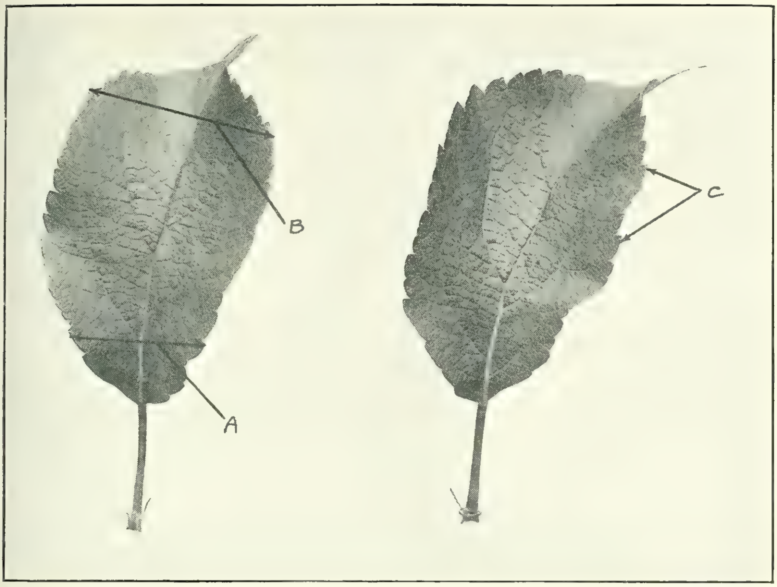

Photo by R. L. Coffin.

FIG. 18. — KING DAVID. Blade small, narrow at base (A), but broader at apex (B), more or less folded and reflexed; serrations moderately sharp, coarse and irregular (C).

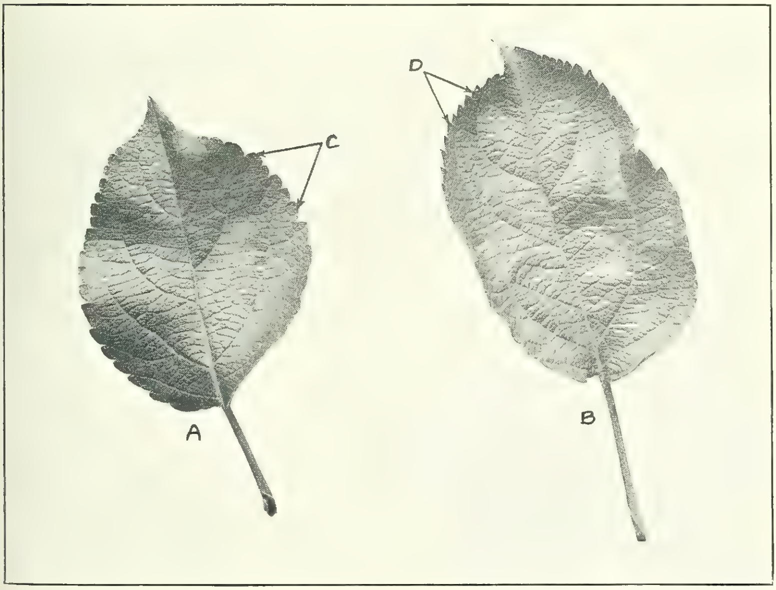

Photo by R. L. Coffin.

FIG. 19. — STAYMAN. Blade medium or below in size, usually nearly round (A), sometimes oblong (B); serrations usually dull and coarse (C), sometimes sharp (D). An exceptional variety, often having leaves of two distinct types.

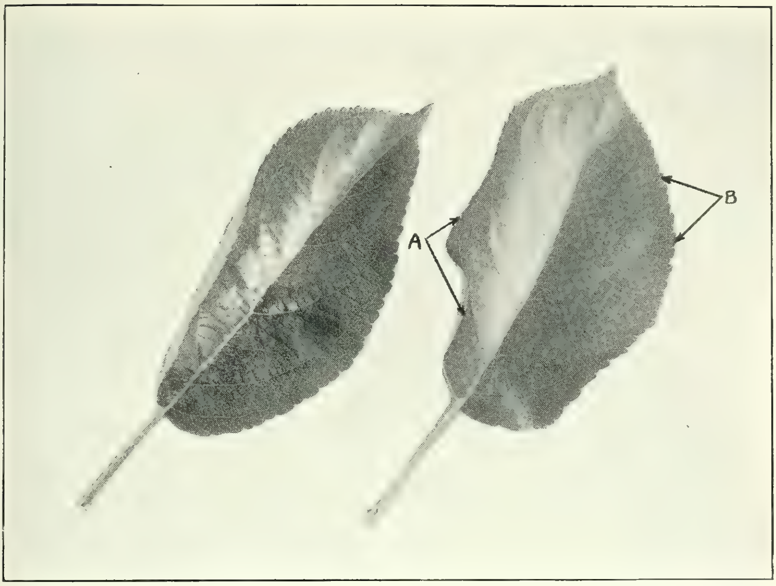

FIG. 20. — OPALESCENT. Blade medium size, somewhat folded, sometimes slightly waved (A); serrations rather dull, fine and regular (B).

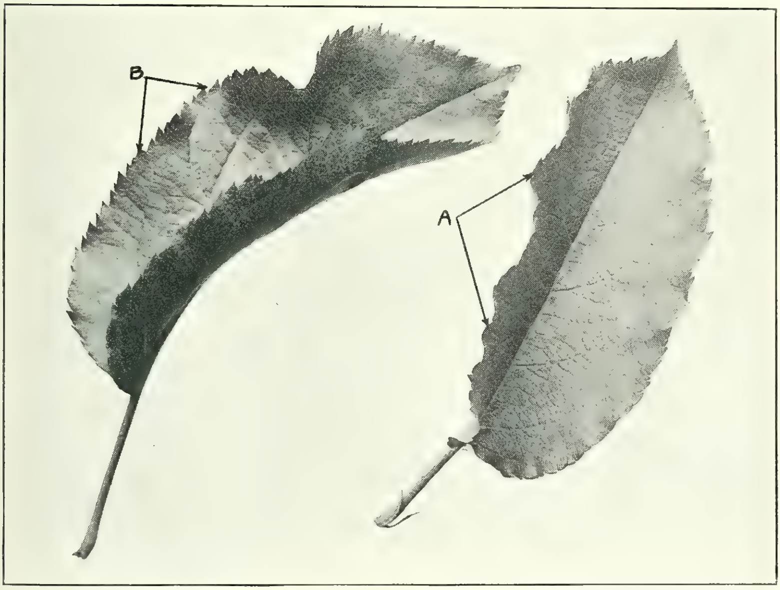

Photo by R. L. Coffin.

FIG. 21. — FALL PIPPIN. Blade large, long and rather narrow, folded, reflexed and waved or wrinkled (A); serrations sharp, coarse and distinct (B).

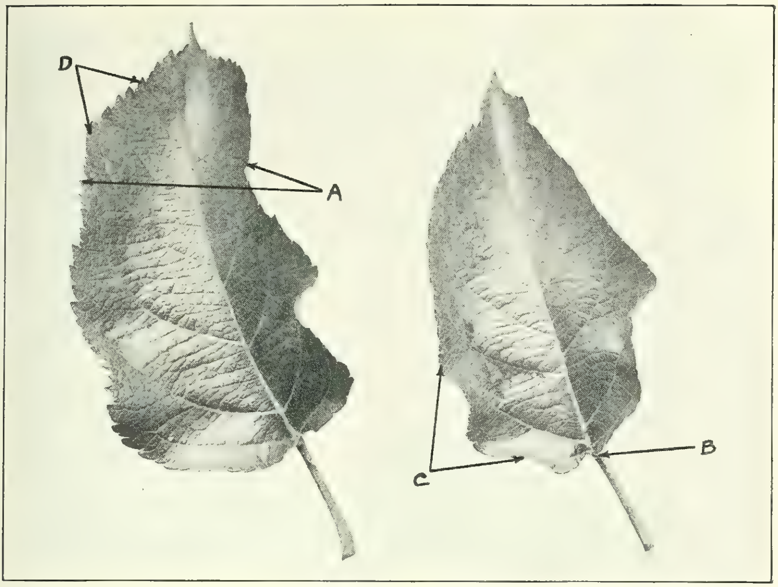

Photo by R. L. Coffin.

FIG. 22. — HUBBARDSTON. Blade medium size, folded (A), reflexed (B), and waved (C); serrations rather sharp and distinct, rather irregular (D).

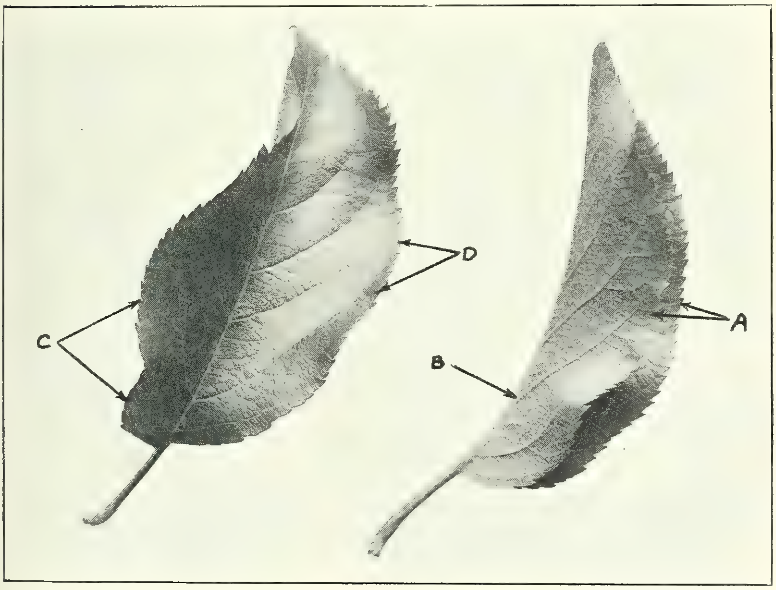

Photo by R. L. Coffin.

FIG. 23. — GRIMES. Blade medium size, folded (A), reflexed (B), and waved (C); serrations sharp, regular and distinct (D).

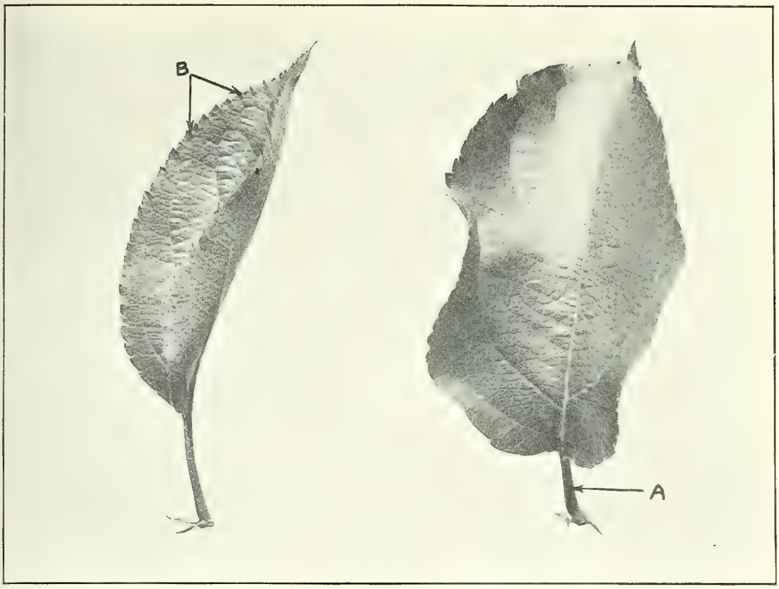

Photo by R. L. Coffin.

FIG. 24. — TOMPKINS KING. Petiole short (A); blade large, folded and reflexed, usually waved; serrations sharp, distinct and quite regular (B).

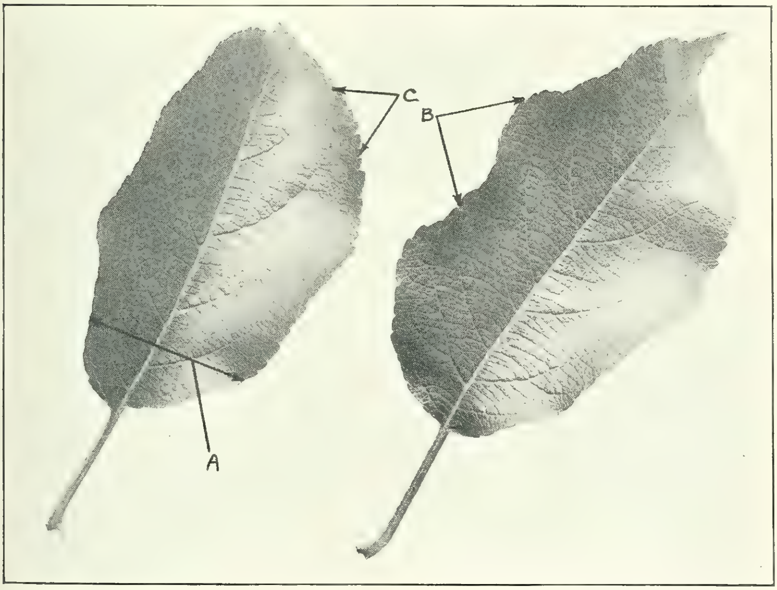

Photo by R. L. Coffin.

FIG. 25. — BEN DAVIS. Blade medium size or above, long and narrow especially at base (A), folded, reflexed and waved (B); serrations dull, rather fine and irregular (C).

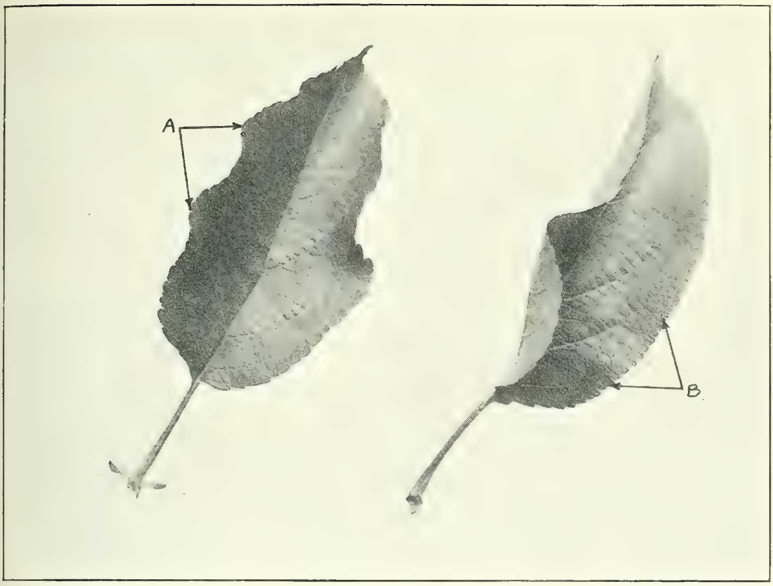

Photo by R. L. Coffin.

FIG. 26. — ESOPUS SPITZENBURG. Blade medium size, folded, reflexed and more or less waved (A); serrations rather dull and quite regular (B).

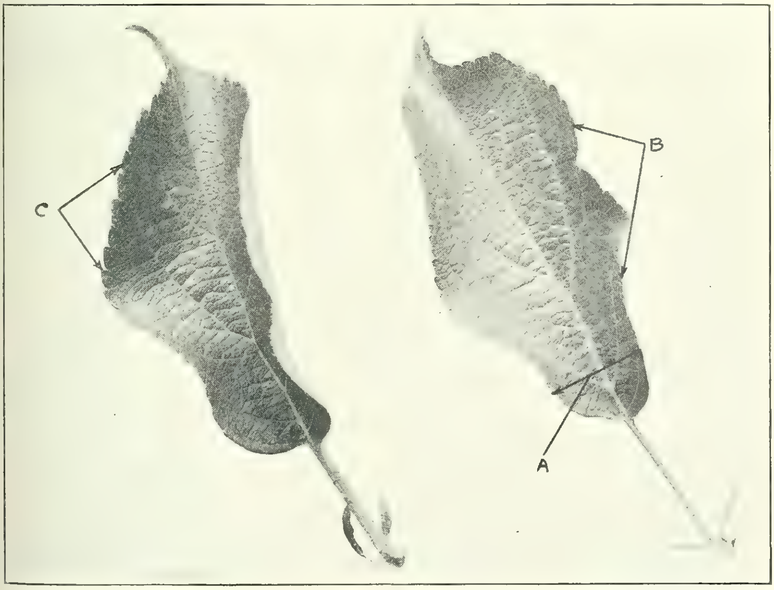

Photo by R. L. Coffin.

FIG. 27. — TOLMAN. Blade medium size, very narrow at base (A), narrow at apex, folded, reflexed and waved (B); serrations rather dull and coarse (C).

Description of Varieties.

There are many leaf characters that are of considerable value in identifying varieties that cannot be well shown in photographs. They have been discussed in the text. In order to present these characters the following technical descriptions of the leaf characters of the varieties illustrated are presented: —

Baldwin. — Petiole medium. Blade above medium size, folded near margin, straight or slightly reflexed, not waved, broad oval, broad at base and very broad at apex, nearly erect, rather thin, smooth, fine texture with little pubescence. Serrations sharp, strongly forward, medium size, fairly regular, usually curved, rather deep and close set. Color medium green. (Fig. 8.)

Ben Davis. — Petiole long, medium size. Blade below medium size, folded, often reflexed, waved, narrow oval, very narrow at base, nearly spreading, rather thin, smooth with considerable pubescence. Serratures dull, moderately forward, rather small and shallow, sometimes slightly curved, quite regular. Color slightly grayish green. (Fig. 25.)

Delicious. — Petiole length, short to medium. Blade below medium size, slightly folded, straight or slightly reflexed, even, ovate, apex narrowing into the point, rather erect, thick, rather coarse texture with little pubescence. Serratures moderately sharp, rather coarse and deep, irregular. Color deep green. (Fig. 14.)

Esopus Spitzenburg. — Petiole medium. Blade below medium in size, more or less folded and waved, slightly reflexed, oval or ovate usually narrowing at apex, medium in texture and pubescence. Serratures rather dull, small and rather shallow, fairly regular. Color medium green. (Fig. 26.)

Fall Pippin. — Petiole medium long, stout. Blade large, folded, reflexed and waved, ovate with apex merging into acute or acuminate point, rather smooth and shining. Serratures sharp, deep and distinct, not curved, rather irregular. Color bright clear green. (Fig. 21.)

Gravenstein. — Petiole medium. Blade large, flat, not waved, oval, smooth and shining. Serratures rather sharp, shallow, fairly regular. Color medium green. (Fig. 2.)

Grimes. — Petiole medium. Blade medium size, strongly folded, waved and reflexed, long and narrow, narrowing at base and apex, rather thin, smooth and shining, with little pubescence. Serrations sharp, distinct and rather deep, rather irregular. Color medium green. Grimes resembles Wagener, but it has less pubescence, is thinner, and has finer and sharper serrations. (Fig. 23.)

Hubbardston. — Petiole rather short, medium size. Blade below medium, folded, more or less waved, reflexed, generally ovate, rounded at base and generally narrow at apex, nearly erect, medium thickness, dull, rather coarse texture with considerable pubescence. Serratures fairly sharp, medium size, moderately deep and distinct, fairly regular. Color deep grayish green. (Fig. 22.)

Jonathan. — Petiole short and rather slender. Blade very small, more or less folded, waved, sometimes reflexed, oval, narrow at base and apex, rather spreading, rather coarse texture with considerable pubescence. Serratures rather dull, rather coarse, shallow and irregular. Color grayish green. (Fig. 17.)

King David. — This is like Jonathan, except that the leaf is somewhat larger, distinctly broader in the apex, less apt to be folded and with somewhat less pubescence. (Fig. 18.)

McIntosh. — Petiole short and rather stout. Blade large, flat or slightly folded near margin, straight, not waved, broad oval, often cordate at base, spreading, rather coarse and thick, with considerable pubescence. Serratures dull, medium size, very shallow at base, fairly regular. Color deep grayish blue green. (Fig. 3.)

Northern Spy. — Petiole generally rather long and slender. Blade medium size,

more or less folded and waved, often slightly reflexed, ovate, erect, rather thin, smooth with little fine pubescence. Serratures rather sharp, medium size, rather shallow, fairly regular. Color clear medium green. (Fig. 16.)

Oldenburg. — Petiole long. Blade above medium to large, more or less folded, slightly reflexed, distinctly waved, broad oval, broad at base and apex, spreading, medium thickness, rather dull surface with medium pubescence. Serratures rather dull, medium in size and depth, irregular. Color medium green. (Fig. 6.)

Opalescent. — Petiole medium. Blade medium size, somewhat folded, sometimes waved, oval, rather narrow at base, apex narrowing into the point, spreading, medium thickness, smooth and shining with little pubescence. Serratures dull, rather small, of medium depth, quite regular. Color medium green. (Fig. 20.)

Red Astrachan. — Petiole medium. Blade large, flat or slightly folded, waved or wrinkled, broad oval, broad at apex, spreading, medium thickness, dull surface with a little pubescence. Serratures dull, medium in size and depth, rather irregular. Color dull medium green. (Fig. 5.)

Rhodé Island Greening. — Petiole long, medium size. Blade large, flat or reverse curved, not waved, broad oval, rounded or narrow at base, broad at apex, spreading or drooping, smooth with little pubescence. Serratures very sharp and distinct, rather deep, fairly regular. Color deep clear green. (Fig. 4.)

Roxbury Russet. — Petiole medium or short, rather stout. Blade medium in size, folded near edge, not waved nor reflexed, broad oval, broad at base and apex, spreading, rather smooth with medium pubescence. Serratures only moderately sharp, rather small, not deep, rather irregular. Color deep green. Much like Baldwin, but the serratures are not so sharp nor so close set and are not curved. (Fig. 9.)

Stayman. — Petiole short to medium. Blade rather small, roundish or broad oval, partly folded, not waved nor reflexed, spreading, rather thick, coarse texture with medium pubescence. Serratures dull and coarse to sharp and small. Color deep green. Stayman seems to be unique in having distinct types of leaves as shown in Fig. 19.

Tolman. — Petiole medium. Blade medium, folded, reflexed and waved, narrow oval, narrow at base and apex, spreading, medium texture with considerable pubescence. Serratures moderately sharp, medium size, quite distinct, generally quite regular. Color deep bluish or grayish green. (Fig. 27.)

Tompkins King. — Petiole rather short and stout. Blade medium to large, folded, more or less waved and reflexed, rather long oval, rather narrow at base and apex, spreading, medium thickness with little pubescence. Serratures sharp, medium to small, shallow and close set. Color medium green. (Fig. 24.)

Wagener. — Petiole, medium or short, stout. Blade medium or above, strongly folded and reflexed, more or less waved, oval with medium base and apex, erect, rather thin with moderate pubescence. Serratures quite sharp, rather coarse, deep and distinct, not curved. Color medium green or slightly grayish. Wagener resembles Grimes, but the leaf is coarser, the serrations not quite so sharp, and it has more pubescence. (Fig. 15.)

Wealthy. — Petiole medium or rather long, slender. Blade medium or above, nearly flat, often somewhat reflexed, often spiral and waved, oval with narrow base and apex, spreading, thick and with little pubescence. Serrations dull, medium in size and depth, somewhat irregular. Color medium green. Wealthy resembles Oldenburg, but the serrations are duller, the blade less folded and much narrower at the base and apex. (Fig. 7.)

Williams. — Petiole medium, rather slender. Blade medium size, partly folded, somewhat reflexed, sometimes coarsely waved, spreading, rather coarse with little pubescence. Serratures dull, small and shallow, regular. Color medium green. (Fig. 11.)

Winter Banana. — Petiole short and stout. Blade medium size, folded near margin, midrib bent at base, not often waved, narrow oval, spreading, medium

thickness with little pubescence. Serrations rather dull and shallow, pointing well forward. Color rather pale green. (Fig. 10.)

Wolf River. — Petiole medium. Blade flat or somewhat folded, often waved and wrinkled, often reflexed, oval, narrow at base and apex, spreading, medium thickness, rather coarse with medium pubescence. Serratures very dull, quite distinct and rather irregular, often double. Color medium green. (Fig. 12.)

Yellow Transparent. — Petiole medium. Blade medium size, more or less folded, often waved and somewhat reflexed, often spiral especially near tips of shoots, rather narrow oval, rather narrow at apex, smooth, rather fine texture with considerable pubescence. Serratures dull, rather small and shallow, quite regular. Color rather paie green. (Fig. 13.)

Glossary.

In the foregoing descriptions there are a number of words that are used in a restricted, technical sense. Definitions of the technical meaning of these words are here given: —

Acute: sharp pointed.
Acuminate: very sharp pointed.
Apex: about one-third of the leaf blade. (See Fig. 1.)
Base: same as apex, but referring to the opposite end.
Blade: the leaf, barring petiole and stipules. (See Fig. 1.)
Cordate: heart-shaped; applied to shape of leaf base. (See McIntosh, Fig. 3.)
Close set: referring to serratures having little space between. (See Baldwin, Fig. 8.)
Curved: applied to "teeth" of serratures. (See Baldwin, Fig. 8.)
Distinct: having spaces between the "teeth" of serratures, the opposite of close set. (See Fall Pippin, Fig. 21.)
Drooping: applied to the angle of leaf and the shoot from which it grows; a very wide angle.
Erect: the opposite of drooping; a sharp angle between leaf and shoot.
Folded: the halves of the leaf curved upward toward each other.
Irregular: serratures of varying sizes.
Midrib: the main vein along the middle of the blade.
Point: the extreme tip of the leaf blade.
Pubescence: the short hairy growth found mainly on the under side of the leaf blade.
Reflexed: having the blade curved backward or downward.
Regular: serratures all of equal size.
Reverse curved: the midrib and blade bent slightly like the letter S.
Serratures, serrations: the notches on the margin of the leaf blade.
Spreading: the usual angle of the leaf and shoot; between erect and drooping.
Spiral: a slight twisting of the leaf blade. (See Wealthy, Fig. 17.)
Texture: applied to the surface of the leaf blade, due mainly to character of the net veins.
Waved: having undulating leaf margins.
Wrinkled: the same as waved, but with smaller undulations.

BULLETIN No. 209.

DEPARTMENT OF POMOLOGY.

EXPERIMENTS IN SOIL MANAGEMENT AND FERTILIZATION OF ORCHARDS.

BY J. K. SHAW.

The Old Station Orchard.[1]

The orchard experiment here reported was begun in 1890 and has continued to the present time. It is, so far as the writer's knowledge goes, the oldest orchard fertilizer experiment in America, and perhaps in the world. The arrangement of the orchard is shown on page 34. It lies on a gentle western slope and is bordered on the west and north by grassland. To the east and south the slope is steeper and covered by a heavy growth of forest trees. The orchard and forest are separated by an open space which in the writer's judgment is sufficient to prevent any injurious influence on the orchard trees from root trespass, though there may possibly have been an injurious effect from shading. This, however, is distributed quite evenly over the whole orchard.

The soil is a strong and retentive gravelly loam underlain by a fairly compact subsoil. It is well supplied with moisture. A ditch above the orchard prevents surface wash from the forest slope above. It was originally somewhat overmoist, especially on plot 3, which is slightly lower than plots 4 and 5. This may have influenced in some degree the growth and yield of this plot, but in the writer's judgment any such influence is small even if it exists at all. Before the trees were planted tile drains were laid to care for surplus water.

[1] This experiment was planned and started by the late Dr. C. A. Goessmann as director and chemist of the State Experiment Station. For most of its life it has been under the direction of Dr. Wm. P. Brooks. The details of management and recording of data have been in the hands of several different men, recently of E. F. Gaskill and R. L. Coffin. The writer is responsible for the tabulation and interpretation of the data.

Below is shown the arrangement of the plots and trees. The trees are spaced 40 × 30 feet, with an additional space of 14 feet between plots. Plot 1 is at the north end of the orchard.

PLOT 1. — MANURE, 10 TONS.

Rhode Island Greening.	Rhode Island Greening.	Rhode Island Greening.
Roxbury Russet.	Roxbury Russet.	Roxbury Russet.
Baldwin.	Baldwin.	Baldwin.
Gravenstein (died before 1907).	Gravenstein.	Gravenstein (died in 1919).

PLOT 2. — ASHES, 2,000 POUNDS.

Rhode Island Greening.	Rhode Island Greening.	Rhode Island Greening.
Roxbury Russet.	Roxbury Russet.	Roxbury Russet (died in 1919).
Baldwin.	Baldwin.	Baldwin.
Gravenstein.	Gravenstein.	Gravenstein.

PLOT 3. — NO FERTILIZER.

Rhode Island Greening.	Rhode Island Greening.	Rhode Island Greening.
Roxbury Russet.	Roxbury Russet.	Roxbury Russet.
Baldwin (died about 1913).	Baldwin.	Baldwin.
Gravenstein.	Gravenstein.	Gravenstein.

PLOT 4. — BONE, 600 POUNDS; MURIATE OF POTASH, 200 POUNDS.

Rhode Island Greening.	Rhode Island Greening.	Rhode Island Greening.
Roxbury Russet (died in 1907–08).	Roxbury Russet.	Roxbury Russet.
Baldwin.	Baldwin.	Baldwin.
Gravenstein.	Gravenstein.	Gravenstein.

PLOT 5. — BONE, 600 POUNDS; LOW-GRADE SULFATE OF POTASH, 400 POUNDS.

Rhode Island Greening.	Rhode Island Greening.	Rhode Island Greening.
Roxbury Russet.	Roxbury Russet.	Roxbury Russet.
Baldwin.	Baldwin.	Baldwin.
Gravenstein.	Gravenstein.	Gravenstein.

Fertilizer Treatment.

Previous to 1889 the soil was in rather poor condition, but had been gradually improved by cultivation in corn and other cereals and grass. The manurial treatment was begun in the spring of 1889, and the following annual applications were continued up to and including 1916. Since 1916 no manure or fertilizer has been applied.

Plot.	Fertilizer.	Pounds per Acre.
1	Barnyard manure	20,000
2	Ashes	2,000
3	Check, no fertilizer	
4	Ground bone	600
	Muriate of potash	200
5	Ground bone	600
	Low-grade sulfate of potash	400

The fertilizer and manure have been applied on various dates, generally between April 1 and May 15, though in 1906 they were not applied until July 2.

Soil Management.

During the period from 1889 to 1893 various crops, such as barley, oats, corn, vetch and soy beans, were grown in the orchard. In the fall of 1893 it was seeded to rye and grass, and the sod then established continued until the fall of 1910. For the first few years small circles around the trees were kept free from grass by hand culture. Until 1902 the grass was cut usually twice each year, made into hay and removed from the orchard. In that year the first crop was made into hay and the second allowed to lie in the orchard. Since 1902 no hay has been removed, but the grass has been cut and allowed to lie where it fell. In November, 1910, four strips, each about 8 to 12 feet wide, were plowed the long way of the orchard. These strips have since been kept in cultivation by harrowing four to eight times during the summer; and usually about August 25 a cover crop of oats or rye has been sown. The grass along the tree rows has been cut and allowed to lie as before.

The history of the soil management, therefore, falls into four periods: —

1. With various intercrops	1889–1893,	5 years.
2. In sod with grass removed	1894–1902,	9 years.
3. In sod mulch	1903–1910,	8 years.
4. In strip cultivation	1911–1920,	10 years.

The fourth period might be subdivided between 1916 and 1917, marking the cessation of the application of fertilizer and manure.

Orchard Management.

The trees have been pruned in most years, at least since they have been in bearing. Heading back the new growth has been practiced more or less, and all dead wood has been removed.

During the early years apparently no spray treatment was given. Beginning in 1902 annual treatments for San José scale have been given which have kept the pest from doing serious damage to the trees. Gen-

erally lime-sulfur has been used for scale control, but in 1912 and 1913 miscible oil was applied in the late fall. This was followed by the dying of branches on some trees, which was attributed in part to the use of the oil, so that it was discontinued. One or two summer sprays have been given except in a very few years when the crop promised to be very light. Curculio injury has been common in most years, and in 1913 the red bug was found to be present. Partial control of these pests has been secured by the use of nicotine preparations in the spray. During the early years copper sulfate preparations and Paris green, and recently lime-sulfur and arsenate of lead, have been used in the summer sprays.

No records of growth were taken previous to 1902. Beginning in that year the circumference of the trunk 6 inches from the ground has been measured annually except in the years 1905, 1906, 1910, 1912 and 1918. Records of the yields of drops and picked fruit for each variety from each plot have been taken each year. The yield of individual trees has not been taken.

Five trees have died since the orchard came into bearing. One Gravenstein in plot 1 died before 1907, and another in 1919. The remaining Gravenstein in this plot was girdled by mice in 1907–08, but was bridge grafted and is now in good condition. One Baldwin in plot 3 died about 1913, one Roxbury Russet in plot 4 died in 1907–08, and one in plot 2 in 1919. (See page 34.) These have all been replaced, but none of the young trees is in bearing. In the tables given for trunk circumference the missing trees are omitted from the averages, but no corrections are made in yields.

Growth Records.

The only record of tree growth is that of trunk circumference which has been taken in most years beginning in 1902. Fig. 1 shows the averages of these measurements by plots. It may fairly be assumed that at the start the trees on the several plots averaged the same size. The differences in 1902 show what happened under the system of sod with removal of the hay. The manure and sulfate plots were alike, averaging about 27 inches. The graph shows that these two plots have steadily diverged up to the present time.

Certain years, such as 1904 and 1908, seem to have been especially favorable to tree growth, while 1917 was unfavorable. The writer has tried to correlate these variations in growth with rainfall, temperature, sunshine and size of crop, but without very much success. It is evident that no one of these factors is entirely responsible.

The relative growth on the different plots is more clearly shown in Fig. 2, where the average trunk circumference of the trees on plot 1 is shown as 100, and that of the other plots as percentages of plot 1. The steady decline of plot 5 from 100 to 89 per cent is clearly shown. Plot (wood ashes) had fallen to about 88 per cent in 1902, and continued to fall off slowly until about 1912, but since that time it has nearly held its own. Plot 4 (bone and muriate) has behaved about the same as plot

The check plot (plot 3) had fallen below 80 per cent at the commencement of our records, and continued to fall off rapidly up to 1911. From 1911 to 1915 it not only kept up with plot 1, but actually gained quite rapidly. Since 1915 it has kept even with plot 1 until the season of 1920, when plot 1 made remarkably strong growth, causing a relative falling off of plot 3 and of the other three plots as well.

The relative gain of plot 3 is beyond doubt due to cultivation of strips between the tree rows begun in the fall of 1910. As shown in Fig. 1, cultivation does not seem to have increased the growth on plot 1, but its effect is seen in all the other plots, though most strikingly in plot 3.

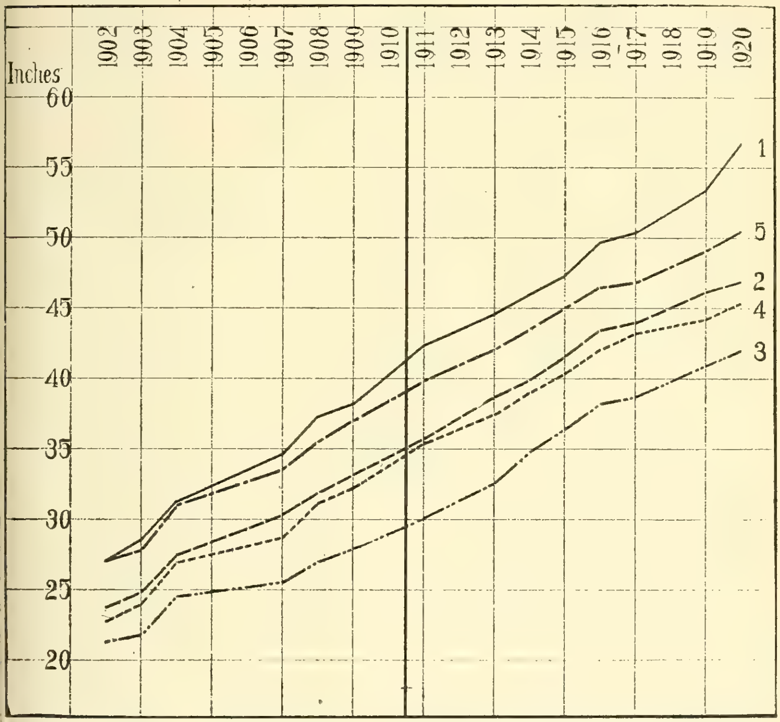

Fig. 1. — Increase in trunk circumferences. The perpendicular line marks the transition from sod mulch to strip cultivation. Plot numbers are shown at the right. See page 35 for treatments given.

No fertilizers of any kind have been applied since 1916, yet the growth on plot 1 has been well maintained as shown in Fig. 1. The other plots show a decrease in rate of growth since 1915, as shown in Fig. 2. It seems doubtful if this can be ascribed wholly to the cessation of fertilizer applications, because the decrease appears first in 1916, when fertilizers were applied, and it is seen in plot 3 which has never had any fertilizer applications. It seems more reasonable to suppose that the relative gain

on plots 2, 3, 4 and 5 since 1911 was due mostly to the stimulus of cultivation which lasted through 1915. From 1915 to 1919 the check plot maintained just about the same growth as plot 1, while plots 2, 4 and 5 fell away. This may indicate an effect of the withdrawal of the fertilizer applications, though, as stated above, the fact that it is seen in 1916 indicates that it is not wholly due to that cause.

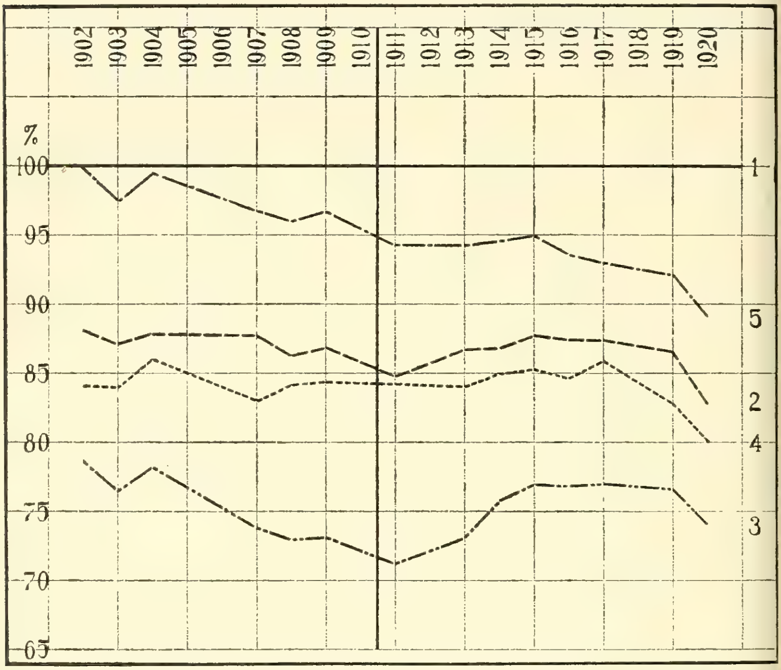

FIG. 2. — Relative trunk circumferences. Circumferences on plot 1 taken as 100 per cent. Plot numbers are shown at the right.

Varietal Response to Treatment.

Turning now to the question of whether all varieties have responded in the same manner to the various fertilizer treatments, we may examine Fig. 3. This shows the average trunk circumferences of the four varieties at three periods: first, in 1902, at the end of the period of hay removal; second, in 1911, at the end of the sod mulch period; third, in 1919, after nine years of partial or strip cultivation.

An examination of these graphs shows that the several varieties have maintained about the same relative positions during the entire period for which growth records have been kept. With increased size of the trees, the absolute differences have naturally increased. Rhode Island Greening has done better on the manure and ashes plots than on the other three

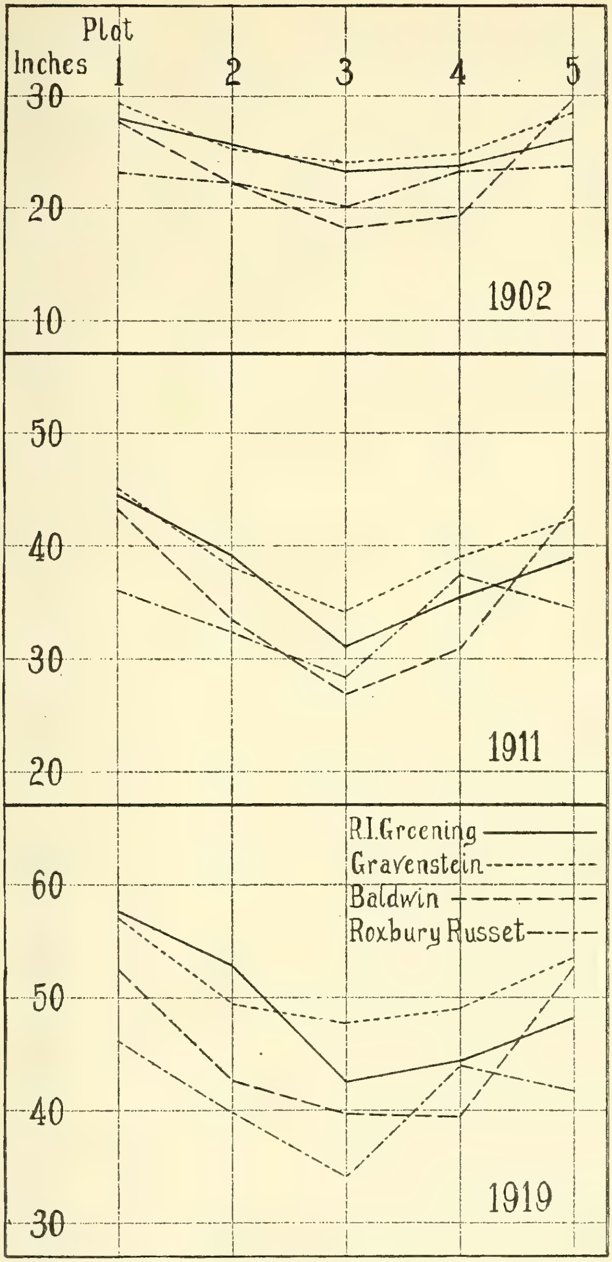

FIG. 3. — Trunk circumferences by varieties. Figures across top are plot numbers.

plots. Roxbury Russet is larger than Baldwin on the muriate plot, and the opposite is true on the sulfate plot, the differences here being quite marked and increasing with the age of the trees.

On the manure plot Rhode Island Greening has gained on the other varieties, which may be due to the fact that it is the outside row with free exposure to the north. On the ashes plot no relative change of the four varieties appears. On the check plot Baldwin has gone ahead of Roxbury Russet during the period of strip cultivation. Gravenstein has increased its lead over the other varieties, especially during strip cultivation. On the sulfate plot Gravenstein has gone ahead of Baldwin during the strip cultivation period, while the other varieties have maintained very much the same relative positions.

While there seem to be some quite marked varietal differences in growth, notably in the Baldwin and Russet on the two potash plots, it would be unsafe to conclude that they are due to the fertilizer treatments. They may be in part, but it is more likely that disease, natural soil differences, or inherent differences in the stocks used may be responsible.

Yield Records.

In Table 1 are given the total yields by plots and by varieties for the periods when no cultivation was practiced, and for the later period of strip cultivation.

TABLE 1. — *Total Yields by Varieties and by Plots (Pounds).*

VARIETIES.	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Totals.
R. I. Greening:						
Before 1912	11,043	5,420	1,471	5,062	5,091	28,087
1912–20	16,989	14,310	7,344	10,367	9,881	58,891
Totals	28,032	19,730	8,815	15,429	14,972	86,978
Roxbury Russet:						
Before 1912	7,832	4,930	1,652	6,010	7,375	27,799
1912–20	12,123	7,620 [1]	4,554	6,954 [2]	8,397	39,648
Totals	19,955	12,550	6,206	12,964	15,772	67,447
Baldwin:						
Before 1912	8,168	4,155	735	2,359	10,936	26,353
1912–20	12,853	10,225	3,515 [3]	5,234	12,616	44,443
Totals	21,021	14,380	4,250	7,593	23,552	70,796
Gravenstein:						
Before 1912	4,308	2,697	1,490	4,412	4,035	16,942
1912–20	3,839 [4]	5,855	5,289	7,175	5,175	27,333
Totals	8,147	8,552	6,779	11,587	9,210	44,275
All varieties:						
Before 1912	31,351	17,202	5,348	17,843	27,437	99,181
1912–20	45,804	38,010	20,702	29,730	36,069	170,315
Totals	77,155	55,212	26,050	47,573	63,506	269,496

[1] One tree died in 1919.
[2] One tree died in 1907.
[3] One tree died in 1913.
[4] One tree died before 1907, and one in 1919.

The yields have been light, averaging only about $2\frac{1}{4}$ barrels per year per tree for the period from 1912 to 1920, inclusive, when the trees were practically mature. Rhode Island Greening has been the heaviest producer, deriving its superiority largely from plots 1 and 2. Baldwin is second, due in part to its superiority on plot 5. Roxbury Russet is third, and Gravenstein fourth, this variety being considerably inferior to the others in yield.

In total yields of all varieties by plots, the order is the same as for the size of the trees measured by trunk circumference. Plot 1 is ahead, followed by plots 5, 2, 4 and 3 in order.

All varieties increased their yield strikingly in the second period on nearly all plots, and especially on plot 3, the unfertilized plot. Here the total yield of all varieties was nearly fourfold. Baldwin increased nearly fivefold despite the loss of one of the three trees in 1913. On plot 1 the increase of all varieties was a little less than 50 per cent, though the yield of Gravenstein fell off, owing to the death of one tree before 1907, and the decline and death of another in 1919. If we assume that the normal increase due to growth of the trees is about 50 per cent, then plot 3 has increased its yield about two and one-half times over its normal, while the increase on plot 2 was about 40 per cent more than this assumed normal increase. Plot 4 has increased slightly more than the normal, while plot 5 has failed to make the normal gain.

There are several suggestive things that can be noted concerning the response of the different varieties to strip cultivation, but the small number of trees involved makes it rather doubtful if these differences have real significance.

The total yield of apples from the five plots from 1902 to 1920, inclusive, is shown graphically in Fig. 4. The heavy crops have been in the odd years, and are shown by heavy lines, while the light yields of the even years are shown by the lighter lines. The heavy perpendicular line between 1910 and 1911 marks the transition from sod mulch to strip cultivation.

This chart shows that in the off years there were no very great nor consistent differences between the plots until the 1920 crop. Nor has there been a very great increase in yield with the larger size of the trees in succeeding years. The off-year crop on the unfertilized plot has been the lowest of all in most years until the last two crops, when it has been about the average of the whole orchard. This better showing probably is the result of the increased growth of these trees since strip cultivation has been practiced. The crop of 1920 was heavier than that in any other off year, and, together with the light crop set in 1921 at the time of this writing, may mark a reversal of the off and on years. In 1920 the crops on the several plots were in much the same order as in the on years.

The off-year yields of the muriate and sulfate plots have been closely parallel, and the same is true of the on-year yields, yet the yields of the muriate plot have been distinctly inferior to those of the sulfate plot. This difference is less since 1911 than before, and may be due merely to

the smaller size of the trees. The manure plot has been the best producer in most years, and its superiority seems to have increased in the last three on-year crops. The ashes plot has approached the manure plot more closely since 1911 than before. The unfertilized plot has been, up to 1920, far in the rear of all the fertilized plots, though showing material gains in on-year yields since 1911, which brought it slightly above the muriate plot in 1919.

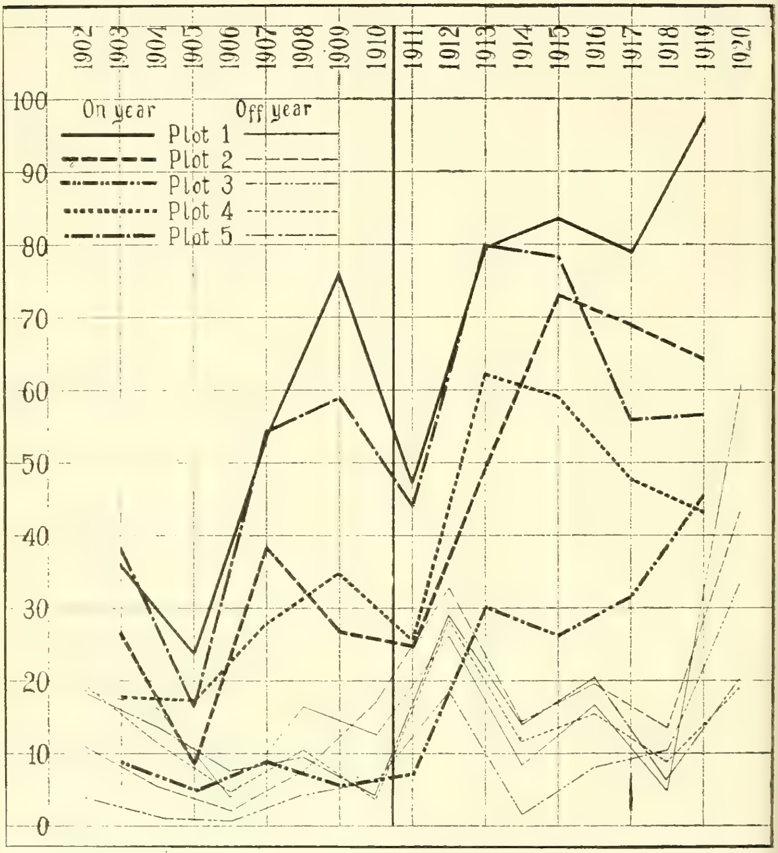

FIG. 4. — Total yields by plots in hundreds of pounds. The odd numbered years are the bearing or "on" years. Figures at left are hundreds of pounds.

It is apparent that the effect of the manurial treatment on yield has been slight in the off years, but in the on years it seems reasonable to conclude that there have been differences in yield due to the different manurial treatments. These differences in the on years follow closely the differences in growth of the trees. It is probable that the fertilized plots have exceeded in yields the unfertilized plot mostly because the trees were larger. The fertilized plots have received greater or less supply of nitrogen.

Many experiments have shown that abundant nitrogen favors the set of fruit. There is also no doubt that on these plots the fruit has been larger than on the unfertilized plot. These additional factors would contribute to the increased yield of the trees on the four fertilized plots. Inasmuch as the trees on the unfertilized plot now approach those of the other plots in size, it is probable that this inferiority would be somewhat less marked in the future were the treatment to be continued as in the past.

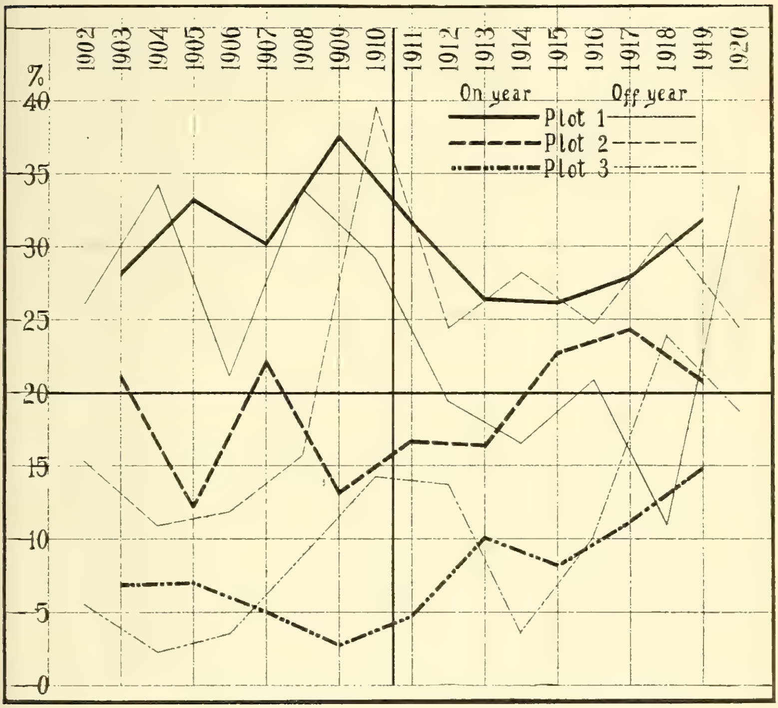

Fig. 5. — Yields by plots in percentages of total yields of the whole orchard. Plots 1, 2 and 3.

It was observed that the ashes, muriate and sulfate plots produced considerable growth of clover while fertilizer applications were kept up. When these ceased in 1916 the clover gradually disappeared. No doubt this growth of clover contributed nitrogen to the trees. The decline in growth and production of these three plots during the last four or five years may have been in some measure due to this lessened nitrogen supply.

The relative yields of the five plots are shown from another viewpoint in Figs. 5 and 6, where the yields are shown in percentages of the total crop of the whole orchard. Fig. 5 shows plots 1, 2 and 3, and Fig. 6 shows plots 4 and 5. Here, again, the heavy lines show the on-year yields and the light lines the off-year yields. Inasmuch as there are five plots, the

horizontal line along the abscissa of 20 per cent shows what we may call the normal yield of each plot.

The manure plot produced from 8 to 17 per cent excess over its normal 20 per cent under sod mulch in the on years, and only a little smaller excess in the off years. Under strip cultivation since 1910 it has fallen to an average excess of about 8 per cent in the on years, and in three of the off years it has failed to produce its normal 20 per cent of the crop. Of course this percentage loss of the manure plot is made up by the other plots, and the ashes plot has helped do this. In all but two of the on years under sod mulch it failed to produce its normal 20 per cent, while in three out of five crops under strip cultivation it has exceeded its normal share. In the off years since strip cultivation its excess is much more marked. The unfertilized plot was far behind under the sod mulch system, but shows fairly consistent gains since strip cultivation has been practiced, and in one of the off years has exceeded its normal 20 per cent.

Effect of Form of Potash. — The muriate and sulfate plots have usually been in close accord in the off years, but in the on years there was marked superiority in the sulfate plot up to and including 1911, with the exception of 1905. Since 1911 the yields of these two plots have not differed widely.

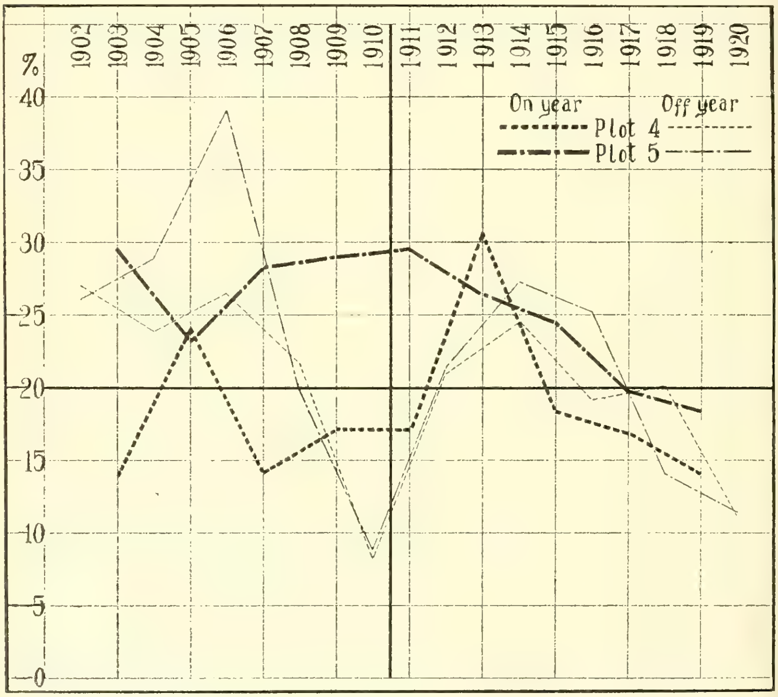

FIG. 6. — Yields by plots in percentages of total yields of the whole orchard. Plots 4 and 5.

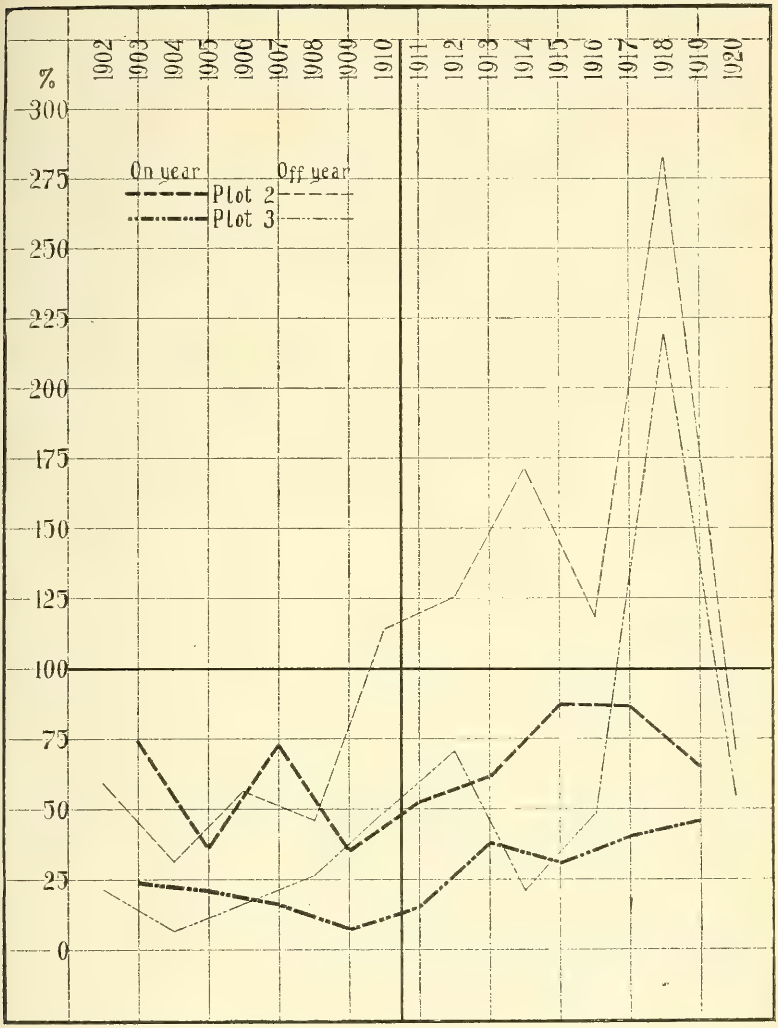

FIG. 7. — Relative yields of plots 1, 2 and 3. Yields on plot 1 taken as 100 per cent.

Whether the wide differences of the crops of 1903, 1907, 1909 and 1911 were accidental, or were due to the different fertilizers used on the sod mulch system then practiced, it is impossible to say. It seems certain that no significant differences have appeared since 1911, and of course the buds for that crop were formed while the plots were handled under the sod mulch system. Both these plots have, since 1913, produced a steadily decreasing proportion of the crop of the orchard.

Still another view of the plot yields is shown in Figs. 7 and 8, which show the yields of plots 2, 3, 4 and 5, with plot 1, the manure plot, taken

as 100. These figures show clearly how plot 1 has often been exceeded by the other plots in the off years and scarcely at all in the on years. The increased production of the ashes and unfertilized plots since strip cultivation was begun is shown. The relative decrease of the ashes and unfertilized plots under sod mulch is shown, and also their gain on the manure plot when strip cultivation was begun. The unfertilized plot still continues a relative increase, while the ashes plot shows a falling away in the last few years. Fig. 8 shows clearly the parallel courses of the muriate and sulfate plots, with a relatively wider difference under sod mulch, and a gradual convergence since strip cultivation has been practiced.

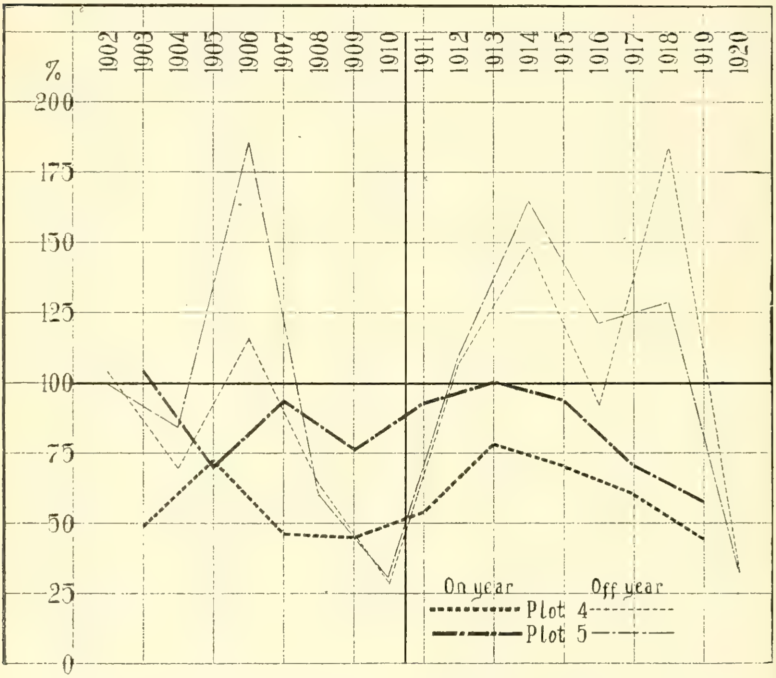

FIG. 8. — Relative yields of plots 1, 4 and 5. Yields on plot 1 taken as 100 per cent.

Correlation between Growth and Yields.

It is interesting to compare these graphs with Fig. 2 showing similar measures of growth as indicated by trunk circumference. Several investigators have shown a close correlation between growth and fruit production. Within limits the two go together, — the more growth the greater fruit production. This conclusion is supported by a comparison of Fig. 2 with Figs. 7 and 8. Especially do the lines representing growth and production

on the unfertilized plot show a general resemblance, both falling off under sod mulch and rising when strip cultivation was begun. There is only a little less striking resemblance in the curves for the other three plots.

Quality.

Considerable differences in quality of the product of the several plots have appeared. This is considered to include size, color, keeping quality and dessert quality. No special records of size have been kept, but observation shows that differences in size have been closely correlated with yield; the apples on plot 3 have been small and those on plot 1 generally larger than those of any other plot. Rarely has the crop on any tree been large enough to limit the size of the fruit.

Brooks[1] reports near the end of the sod mulch period: —

In color and general attractiveness of appearance the fruit of the several plots has usually ranked in the following order: plots 2, 5, 4, 1 and 3. In the early years of the experiment the rank of the fruit in size was in the order: plots 5, 4, 1, 2 and 3. At the present time (1909) the apples on plot 1 take a higher relative rank, and in all cases where the quantity of fruit is not excessive the apples on plot 1 are usually larger than on any of the other plots.

A number of tests of keeping quality have been made, and in this respect the fruit has usually ranked in about the following order: plots 5, 4, 1, 2 and 3. The relatively low rank of the fruit from plot 2 in keeping quality appears to be connected with the fact that this fruit comes to maturity earlier than that on the other manured or fertilized plots. It will be noted that the fruit from plot 2 ranks highest in appearance. This is due to its superiority in coloring. This in turn is undoubtedly connected with the fact that the fruit is somewhat more mature. Such fruit might undoubtedly be kept if promptly put into cold storage; but in ordinary storage it is considerably inferior to the somewhat less thoroughly ripened fruit on the other manured plots.

The fruit from plot 5 has almost invariably been much superior in appearance to that produced on plots 1 or 4. Here again there have been individual variations in the product of the different trees of the same variety on all of the different plots. There has, however, been no doubt as to the fact that on the whole the product of plot 5 has been considerably superior in color and general attractiveness as well as in firmness of flesh to the product from plot 4; while the product from plot 1, which receives barnyard manure, ranks below either of the others in the qualities just mentioned. In general, the fruit produced on plot 5 shows a considerably brighter and clearer color than that on either plots 4 or 1. There can be no doubt that it would sell at a higher price in the general market than either of the others, although the difference between plots 4 and 5 is considerably less than between plots 1 and 5. The product of the unmanured plot, 3, shows good color and in some cases is of fair size, but in general is too small to command the best prices.

At the present time, after ten years of strip cultivation, these differences between the several plots are not as marked as during the sod mulch period, yet they continue in considerably reduced degree.

[1] Mass. Agr. Expt. Sta., Ann. Rept. 22, Pt. 2, p. 14 (1910).

The Graves Orchard.[1]

As the experiment above reported progressed, marked differences appeared between plots 4 and 5, the muriate and sulfate plots. Though these differences became less in later years, in 1907 they appeared important enough to justify further investigation. Accordingly a ten-year lease of a young Baldwin orchard, located in the southeastern part of the town of Amherst about six miles distant from the Experiment Station, was secured.

An experiment was planned to show whether differences similar to those which had appeared between plots 4 and 5 would appear here also, and whether, if such differences did appear, they were due to the form of the potash, which was muriate in one case and sulfate in the other, or to the presence of magnesium in the low-grade sulfate of potash.

The site of the orchard was a gentle northeasterly slope, with the steep slope of the easterly end of the Holyoke mountains about 40 rods to the south. The soil was a medium sandy loam rather low in fertility.

The trees, with the exception of four scattered trees, were of the Baldwin variety, and were said to be six years old at the beginning of the experiment. While most of the trees were fairly uniform at the start, there were a number of poor stunted trees which died or were replaced with new trees early in the experiment. None of these young trees bore fruit during the experimental period, and they are omitted in the consideration of the results. A plan of the orchard is shown in Fig. 9.

The orchard was in sod when taken over, but it was plowed in the spring of 1908, and in the following years handled in a system of cultivation and non-leguminous cover crops. As shown in the plan a strip on the north end was left in sod during the whole period.

Fertilizer Treatment.

In the spring of 1908 the orchard was laid out in eight plots of two rows each, and application of fertilizers made as shown in Fig. 9. Application of these materials at the given rates was made annually during the first half of May, beginning in 1908 and continuing for six years. In 1914 the applications to row 2 of each plot were discontinued, and the amounts given to row 1 of each plot reduced to one-half the former amounts. This plan was followed for four seasons until the expiration of the lease ended the experiment.

The circumference of the trunks 1 foot from the soil was taken in the spring of 1908; in April, 1914; in April, 1916; in November, 1917; and in August, 1921.

The first crop of fruit was produced in 1911. This was followed by a very light crop in 1912 and moderate crops in 1914, 1915, 1916 and 1917. Yield records were taken by plots, omitting the four odd trees mentioned

[1] This experiment was planned by Dr. Wm. P. Brooks, then director of the Experiment Station. The data were taken under the direction of Prof. F. C. Sears and E. F. Gaskill. The writer is responsible for the tabulation and interpretation of the data.

GRAVES ORCHARD

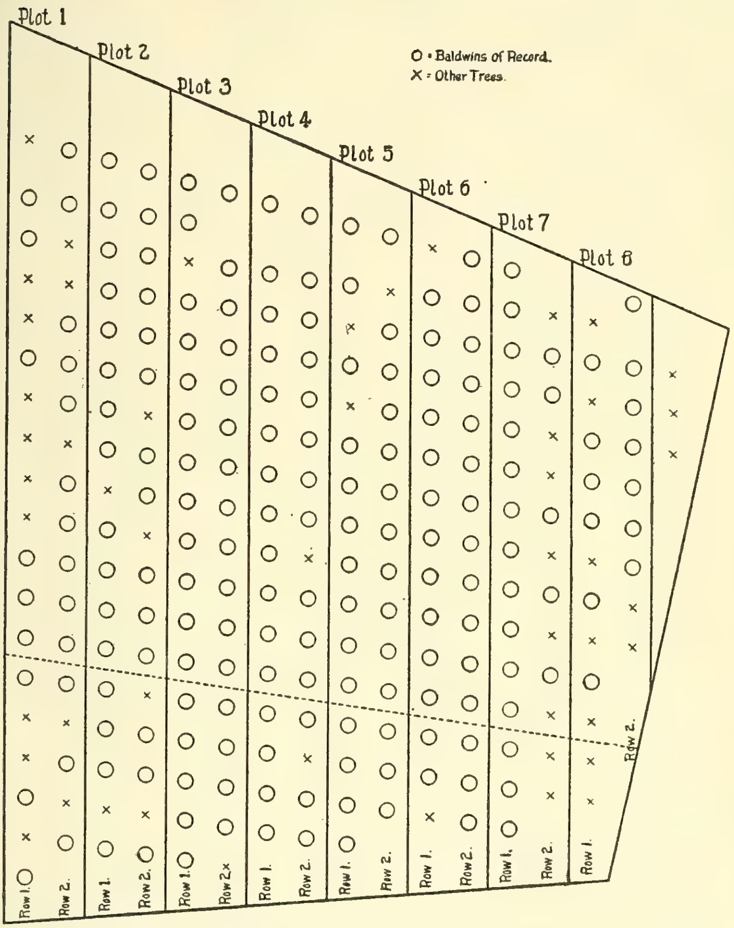

FIG. 9. — Plan of the Graves orchard. The portion below the dotted line was in sod.

Fertilizer Treatment per Acre.

Plot 1.	Manure	8 tons
Plot 2.	Ashes	1,600 pounds
Plot 3.	No fertilizer.	
Plot 4.	Bone	600 pounds
	Muriate of potash	160 pounds
Plot 5.	Bone	600 pounds
	Low-grade sulfate of potash	320 pounds
Plot 6.	Bone	600 pounds
	Muriate of potash	160 pounds
	Sulfate of magnesia	255 pounds
Plot 7.	Bone	600 pounds
	High-grade sulfate of potash	160 pounds
Plot 8.	Basic slag	800 pounds
	Low-grade sulfate of potash	320 pounds

above. Individual tree records of yield were not taken, nor was any separation made of the yields of that portion of the trees remaining in sod. In the early years no separate record of dropped and picked fruit was made, but in the last four years the picked fruit was recorded separately.

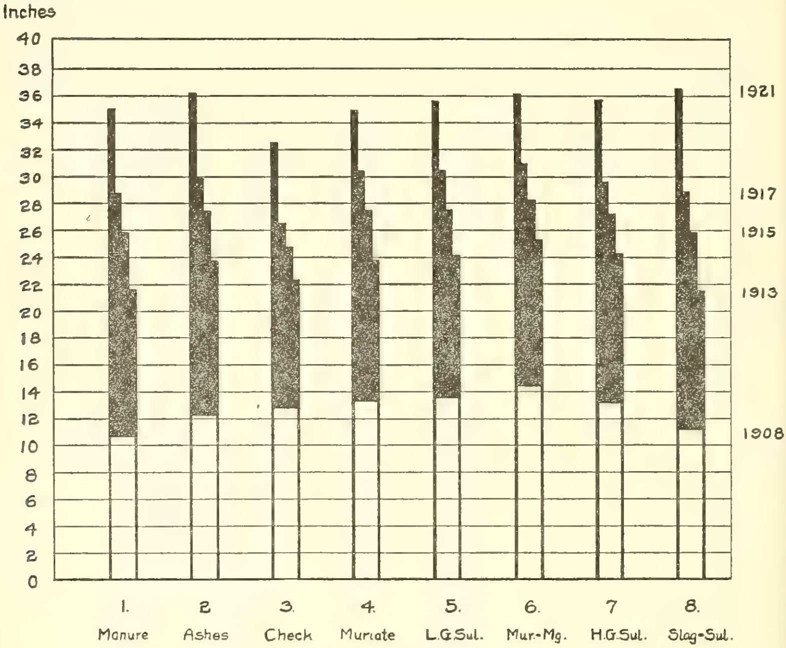

FIG. 10. — Average trunk circumference by plots, cultivated Baldwin trees only (Graves orchard).

Growth Records.

Fig. 10 shows the increase in trunk circumference of the trees in cultivation in the several plots. The growth on plot 3, the check plot, has been less than on the other plots, indicating that the trees responded to the application of all the fertilizers by increased growth. At the beginning of the experiment the trees on plot 3 were exceeded in size by those on plots 4, 5, 6 and 7. In 1917, at the end of the period of fertilization, this difference had increased somewhat, while the trees on plots 1, 2 and 8 had grown so that the check plot then had the smallest trees of any plot. A later measurement of the same trees made in August, 1921, showed that the check trees were still the smallest. It is interesting to note that plots 1, 2 and 8 are the only plots that showed greater growth than the check plot in this four-year post-experimental period.

One seems justified in concluding that on these Baldwin trees under cultivation the fertilizer applications have caused greater growth, and that manure and lime-carrying fertilizers have been more beneficial than those chemical fertilizers which carried no lime.

As has been stated, there was a strip across the north ends of the plots that remained in sod during the entire experimental period. The trees on this strip made considerably less growth than those in cultivation, as shown in Table 2.

TABLE 2. — *Average Increase in Trunk Circumference, 1908–17.*

Plot.	Treatment.	Trees in Sod.		Trees in Cultivation.	
		Number.	Increase in Circumference.	Number.	Increase in Circumference.
1	Manure	6	15.2	16	18.1
2	Ashes	7	14.5	24	17.6
3	No fertilizer	9	11.0	25	13.7
4	Bone and muriate	7	12.6	23	17.2
5	Bone and low-grade sulfate	9	12.1	21	16.9
6	Bone, muriate and magnesia	7	12.8	23	16.4
7	Bone and high-grade sulfate	4	14.5	17	16.4
	Averages and totals	49	13.3	149	16.6

The trees on plot 7 made relatively more growth in sod than those on the other fertilized plots, but owing to the small number of trees involved there is a question if the difference is significant. With this one exception the two series of plots parallel each other very closely. The parallel between plots 4 and 5 is very close. As previously stated, there was some indication that in the station orchard, under sod or sod mulch conditions, low-grade sulfate of potash was superior to muriate. In this orchard, what slight difference there is is reversed in both the sod and cultivated portions of the plots.

It has been stated that in 1914 and following years row 2 of each plot received no fertilizer, while row 1 of each plot received only one-half the amounts previously applied. Table 3 shows the average increase in trunk circumference of the trees in cultivation; no dependable comparison can be made of those in sod because of too few trees.

TABLE 3. — *Average Trunk Circumference of Trees in Cultivation, All Plots except Check (Inches).*

Row.	Treatment.	1913.	1915.	1917.
1	One-half previous amounts	23.50	27.26	30.19
2	No fertilizer	22.94	26.68	29.24
	Difference	.56	.58	.98

These figures indicate a slight response in circumference increase apparently due to the fertilizers, but not enough to be of much significance.

Yield Records.

The yield records of this orchard have been kept by plots only. Inasmuch as the plots are of different sizes and include different numbers of trees, it seems best to divide the total plot yields by the number of bearing trees, thus obtaining the average yield per tree. The average total yield per tree is shown in Table 4.

TABLE 4. — *Average Yields per Tree (Pounds).*

Plot.	Treatment.	1911.	1912.	1914.	1915.	1916.	1917.	Average.
1	Manure	92	15	117	224	328	158	156
2	Wood ashes	217	44	211	221	316	133	191
3	No fertilizer	234	67	101	188	102	223	153
4	Bone and muriate	188	38	66	390	213	268	194
5	Bone and low-grade sulfate	114	55	334	212	347	141	201
6	Bone, muriate and magnesia	251	58	418	195	332	191	241
7	Bone and high-grade sulfate	279	45	338	260	200	159	214
8	Slag and low-grade sulfate	163	11	334	175	387	221	215

The lowest yield is from the unfertilized plot, 3, and the highest yield is from the muriate and magnesium plot, 6. Plots 4 to 8 show rather uniform yields, varying from 194 to 241 pounds per tree, and it is probably unsafe to attribute the differences that do show to the differential fertilizer treatment. The yield from the ashes plot (189 pounds) is only a little below that of these plots, and may or may not indicate that this fertilizer treatment was less effective in producing apples than the treatments given to plots 4 to 8. The yield on the manure plot is low and may indicate an inferiority of manure as fertilizer on this soil, yet it should be noted that these trees were at first the smallest in the orchard, and at the end of the experimental period were exceeded in trunk circumference by all except those on the unfertilized plot. Plots 4 and 5 received practically the same fertilizer treatments as plots 4 and 5 in the station orchard, the results from which this experiment was planned to explain. The difference in yield is here only 7 pounds per tree, a degree of similarity rarely secured from plots receiving identical fertilizer treatments.

Fig. 11 shows the average yield per tree by two-year periods, — 1911 and 1912, 1914 and 1915, and 1916 and 1917, — there being no crop in 1913. The most significant fact brought out here is that the unfertilized plot shows practically the same yield for each period, while the fertilized plots all show substantial gains for the second two periods over the first. The slag-sulfate plot, 8, shows a large gain, and the manure plot, 1, makes

a better showing from this viewpoint than from that of average total yields per tree. The ashes plot, 2, made a substantial gain during the second period, but made little further gain in the third period.

It seems reasonable to conclude that under the conditions at this orchard, which is on a sandy soil of inferior fertility, as indicated by the growth of cover crops and other herbaceous plants, the fertilizers applied have been beneficial to the trees, as indicated by increased growth and greater production.

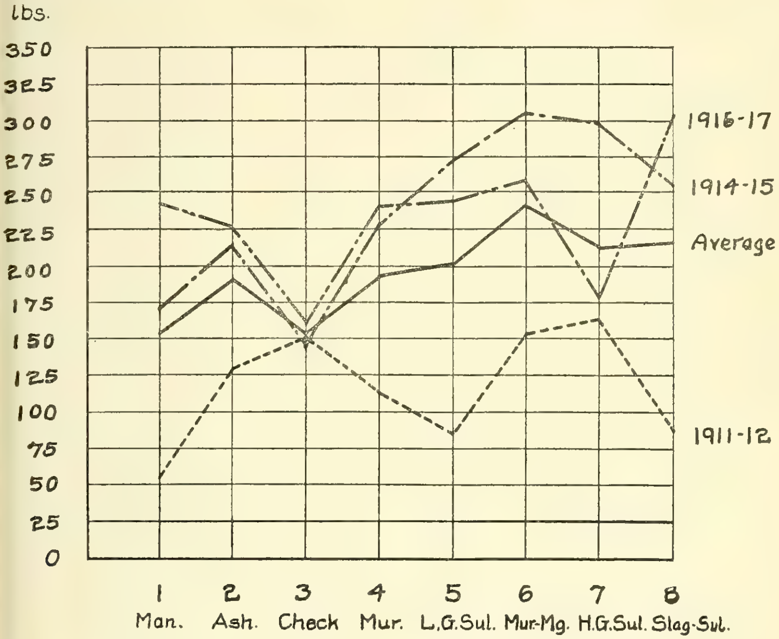

FIG. 11. — Average yield per tree by two-year periods (Graves orchard).

Discussion of Results.

The results of many orchard fertilizer experiments in this country have shown that, of all the fertilizer elements usually taken into consideration, nitrogen is most likely to produce a response. This response appears in darker colored and more luxuriant foliage, more growth, and often increased production of fruit. It may be worth while to consider how far the observed results, especially those of growth, can be explained on the basis of variation in available nitrogen supply.

The manure plot in the station orchard has plainly responded to the generous supply of nitrogen it has received. Growth, foliage color, and size and color of fruit have all been typical of trees well supplied with nitrogen. Both the potash plots in this orchard have received small supplies of nitrogen in the ground-bone application of 600 pounds per

acre. This amount of bone supplies only about one-tenth as much nitrogen as plot 1 has received, and yet it is doubtless enough to account in part, at least, for the greater growth than that observed on the unfertilized plot. The uniformity of the several potash plots in the Graves orchard indicates that this may have been a nitrogen response rather than one to potash. All indications are that the Graves orchard soil is deficient in nitrogen, and a small supply of this element might be expected to produce marked results.

The relatively strong growth of the trees on the ashes plots and on the slag-sulfate plot in the Graves orchard indicates that added nitrogen cannot wholly account for the greater growth of the fertilized trees. Probably the presence of lime has favored greater availability of the nitrogen-carrying humus, even though this may have been present in only small amount in this soil, and so operated to increase the nitrogen available for the trees. The striking response to cultivation of the trees on the unfertilized plot in the station orchard may be fairly taken to indicate that lime is not always necessary to render the humus nitrogen available.

Manure has had a more persistent residual effect in both orchards than the other materials used. Evidently the effect of greater nitrogen supply because of cultivation, on plots not receiving manure, lasted about five years, after which the nitrogen supply was insufficient to maintain the increased growth of the trees.

The fact of inferior growth and production of the muriate plot in the station orchard as compared with the low-grade sulfate plot is interesting, and seems to have been peculiar to sod mulch management. Its inferiority apparently disappeared when the soil was cultivated. There is no evidence of such a difference on the lighter, better-drained soil of the Graves orchard. It is probable that this superiority of the low-grade sulfate was a real one. It has been suggested that the difference was due to the poorer drainage of the muriate plot. But the adjoining unfertilized plot is still more inferior in this respect, and yet this plot gave very good results when strip cultivation was adopted. It has been shown that muriate of potash may exert a depressing effect on nitrification, and this may possibly explain the results obtained. The attempt to explain whether this difference was due to the difference in the form of potash or to the presence of magnesium in the low-grade sulfate was unsuccessful, as no significant differences were obtained in the Graves orchard even with the trees in sod. The Graves orchard received a lighter application of potash and for a shorter period of years. Possibly this may have been a factor in bringing about different responses.

Summary.

1. In the two orchard experiments here reported, growth and fruit production were closely correlated. Increased growth was followed by increased production.

2. In one of the orchards, trees in cultivation gave better growth and higher production than when in sod.

3. In a sod orchard, low-grade sulfate of potash gave better results than muriate of potash, both plots receiving also ground bone. With strip cultivation this difference seemed to disappear. In a cultivated orchard, on lighter, better-drained soil, no significant differences appeared. On the sod portion of this second orchard, furthermore, there were no material differences.

4. The residual effect of manure was greater than that of ashes or the chemical fertilizers used.

APPENDIX.

Here are given the original data on which the discussion in this paper is based.

TABLE I. — *Station Orchard: Tree Circumferences (Inches).*

Rhode Island Greening.

Tree.	Plot 1.			Plot 2.			Plot 3.			Plot 4.			Plot 5.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1902[1]	Av. 28.0			Av. 25.5			Av. 23.2			Av. 23.7			Av. 26.2		
1903[1]	Av. 30.3			Av. 27.0			Av. 23.6			Av. 25.9			Av. 27.0		
1904[1]	Av. 33.0			Av. 29.8			Av. 26.1			Av. 28.2			Av. 30.8		
1907	36.5	34.3	38.8	33.5	29.5	37.0	26.5	20.8	34.3	30.0	23.0	35.5	29.0	34.5	34.0
1908	39.0	38.0	41.0	35.0	30.8	39.3	28.0	21.5	35.8	31.5	25.0	37.0	31.5	36.5	37.0
1909	40.5	40.0	42.5	36.5	32.0	40.8	28.5	21.5	36.8	32.5	26.5	38.5	32.5	38.5	37.8
1911	44.0	44.3	45.5	38.5	35.0	43.8	30.5	23.3	39.5	35.5	29.8	41.3	35.0	41.8	40.3
1913	46.0	48.5	48.0	42.5	37.0	47.5	32.0	25.0	43.0	37.5	32.0	43.3	36.0	42.5	44.0
1914	48.0	49.5	49.3	44.5	38.5	49.8	33.8	26.0	44.3	38.8	33.8	44.8	36.8	44.5	46.0
1915	49.3	52.3	51.3	46.8	40.0	51.3	36.0	27.5	46.5	40.0	35.8	46.0	38.3	45.0	47.5
1916	52.3	55.5	54.0	49.5	42.0	54.0	37.5	29.3	49.5	42.0	37.5	48.0	39.8	47.3	50.0
1917	52.5	55.5	54.0	50.0	42.3	55.0	38.3	30.3	49.8	42.3	38.0	48.0	40.0	47.5	50.0
1919	56.0	59.5	57.8	54.3	46.8	57.5	40.5	32.8	53.0	43.0	40.5	49.5	42.0	50.0	53.0
1920	57.5	59.8	58.5	55.5	45.8	58.3	41.3	33.5	53.5	44.0	41.5	50.8	43.0	51.5	54.5

Roxbury Russet.

Tree.	Plot 1.			Plot 2.			Plot 3.			Plot 4.			Plot 5.		
1902[1]	Av. 23.2			Av. 22.3			Av. 20.0			Av. 23.3			Av. 23.8		
1903[1]	Av. 24.0			Av. 23.0			Av. 20.4			Av. 24.0			Av. 24.8		
1904[1]	Av. 26.8			Av. 25.0			Av. 22.6			Av. 26.4			Av. 26.9		
1907	30.0	29.5	30.0	27.5	28.5	27.0	21.0	26.0	24.0	28.8	33.5	23.3	30.5	29.5	28.0
1908	32.0	31.5	30.5	28.5	29.5	28.3	22.0	27.5	25.5	30.0	35.0	23.3	32.0	30.8	29.8
1909	32.8	32.8	32.8	29.8	30.5	29.3	22.5	28.5	26.8	31.0	36.3	[2]	33.0	31.8	30.5
1911	35.0	36.0	37.0	32.5	32.8	32.0	24.5	31.3	29.0	34.8	40.0		35.5	34.0	33.5
1913	37.8	38.8	39.5	34.5	34.5	33.0	25.5	33.0	31.0	36.5	41.3		37.0	36.0	35.0
1914	39.3	40.3	40.5	35.8	35.5	34.0	28.8	33.5	31.8	37.8	45.3		38.0	37.3	36.0
1915	40.5	41.3	41.5	37.0	37.0	36.0	28.0	34.5	32.5	39.5	43.8		39.8	38.5	37.5
1916	42.5	43.0	44.0	38.5	38.8	37.5	28.8	36.3	33.3	40.5	45.0		40.5	39.8	39.0
1917	42.5	43.0	45.0	38.5	38.8	37.5	29.0	36.3	33.5	40.5	45.0		40.8	40.0	39.0
1919	45.5	45.3	47.5	40.5	40.3	39.0	30.3	37.3	35.0	42.3	46.0		42.8	42.3	40.5
1920	47.3	46.8	48.5	[2]	41.0	39.8	31.0	37.8	36.0	43.3	47.8		43.8	43.3	41.8

[1] Measurements of individual trees for these years not available. [2] Tree died.

TABLE I. — *Station Orchard: Tree Circumferences (Inches)* — Concluded.

Baldwin.

Tree.	Plot 1.			Plot 2.			Plot 3.			Plot 4.			Plot 5.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1902[1]	Av. 27.7			Av. 22.3			Av. 18.2			Av. 19.3			Av. 29.8		
1903[1]	Av. 29.1			Av. 23.3			Av. 19.0			Av. 20.3			Av. 31.2		
1904[1]	Av. 32.5			Av. 25.9			Av. 21.4			Av. 23.1			Av. 34.3		
1907	36.5	36.0	34.0	28.8	25.5	31.3	24.8	23.5	19.8	21.5	30.0	23.5	38.0	33.0	40.3
1908	39.5	39.0	36.0	30.0	27.5	32.8	25.5	25.5	21.0	23.0	32.0	25.3	40.0	34.5	42.8
1909	40.5	40.0	36.5	31.0	28.3	34.0	26.0	26.5	23.0	24.0	33.3	26.3	41.8	35.5	44.0
1911	44.0	44.8	41.0	33.0	31.3	36.0	28.0	29.0	23.8	27.8	36.5	28.5	45.3	38.0	47.5
1913	47.0	47.3	41.0	35.5	34.0	39.0	29.5	34.0	24.0	28.5	39.0	30.8	48.8	39.5	51.0
1914	48.0	48.5	42.3	37.0	35.3	40.0	30.8	35.5	[2]	29.8	40.0	32.0	50.5	41.0	52.0
1915	49.5	50.0	43.3	38.5	37.0	41.5	32.3	38.0		31.0	42.0	33.5	52.0	42.8	53.5
1916	51.5	52.5	45.0	40.0	39.0	43.0	33.5	40.3		32.5	43.5	35.3	53.5	43.3	55.5
1917	52.5	53.3	45.3	40.5	39.5	43.0	33.8	41.0		32.8	44.3	36.0	54.0	43.5	55.8
1919	54.8	56.5	47.0	42.3	41.5	44.5	35.5	44.0		34.8	46.3	37.5	56.0	44.8	58.0
1920	56.8	58.3	48.0	43.3	42.5	45.5	36.5	46.0		35.3	47.5	38.5	56.8	46.0	60.0

Gravenstein.

Tree.	Plot 1.			Plot 2.			Plot 3.			Plot 4.			Plot 5.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1902[1]	Av. 29.5			Av. 25.3			Av. 24.0			Av. 24.8			Av. 28.5		
1903[1]	Av. 31.0			Av. 26.3			Av. 24.5			Av. 25.9			Av. 28.5		
1904[1]	Av. 33.8			Av. 29.4			Av. 28.0			Av. 30.1			Av. 32.6		
1907	36.0	40.0	2.5	30.3	32.5	34.0	26.0	29.0	31.8	31.0	35.0	30.5	33.0	37.8	35.5
1908	39.3	42.0	3.5	32.0	34.0	35.8	27.0	30.8	34.0	32.5	37.5	32.3	35.0	39.5	37.3
1909	40.5	42.0	3.5	33.5	35.8	37.5	28.5	32.0	35.3	34.3	39.5	33.0	36.8	42.0	40.3
1911	43.8	46.3	7.0	36.0	38.5	40.3	30.5	34.5	37.3	37.5	43.5	36.0	40.3	43.8	43.0
1913	47.5	49.5	12.0	39.5	42.5	43.0	34.0	37.8	43.0	39.5	47.0	37.5	41.8	48.5	45.0
1914	48.0	52.5	12.0	41.0	43.8	44.3	35.3	39.3	44.8	41.5	48.0	38.5	43.5	50.3	46.8
1915	49.0	53.5	[2]	43.0	45.5	45.8	37.5	41.5	47.0	43.0	50.0	40.0	44.8	52.0	48.5
1916	50.5	56.5		45.0	47.8	47.5	39.0	43.0	50.0	45.0	52.3	41.3	46.0	54.0	50.5
1917	50.5	60.0		45.8	48.0	47.8	39.3	44.0	51.0	45.3	52.5	41.5	46.0	54.8	51.0
1919	50.0	64.0		48.0	50.3	50.0	42.0	46.8	54.5	47.3	55.5	44.3	48.5	59.0	53.3
1920	[2]	66.5		49.3	51.3	51.0	43.3	48.8	55.5	48.8	57.0	45.3	49.5	61.0	55.5

[1] Measurements of individual trees for these years not available. [2] Tree died.

TABLE II. — *Station Orchard: Total Yields by Plots (Pounds).*

Rhode Island Greening.

	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Totals.
Before 1902	270	45	41	130	85	571
1902	777	272	65	521	260	1,895
1903	970	891	394	435	945	3,635
1904	972	139	34	566	297	2,008
1905	596	168	101	338	79	1,282
1906	274	39	27	419	52	811
1907	1,496	973	226	760	798	4,253
1908	948	232	85	328	270	1,863
1909	2,157	1,165	140	604	1,087	5,153
1910	806	334	84	146	101	1,471
1911	1,777	1,162	274	815	1,117	5,145
1912	864	922	811	1,220	747	4,564
1913	1,546	2,196	718	1,354	2,111	7,925
1914	325	194	93	259	189	1,060
1915	2,859	2,467	1,109	2,271	2,240	10,946
1916	761	338	378	188	210	1,875
1917	3,370	2,820	1,191	1,846	1,813	11,040
1918	123	226	135	124	76	684
1919	3,150	2,389	1,097	1,529	1,055	9,220
1920	3,991	2,758	1,812	1,580	1,440	11,581

TABLE II. — *Station Orchard: Total Yields by Plots (Pounds)* — Concluded.

Roxbury Russet.

	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Totals.
Before 1902	269	119	39	251	291	969
1902	874	631	269	1,235	1,023	4,032
1903	703	567	330	608	1,067	3,275
1904	391	384	5	396	410	1,586
1905	548	206	165	621	769	2,300
1906	128	61	8	26	68	291
1907	1,361	1,295	313	903	1,389	5,261
1908	328	78	71	270	232	979
1909	1,719	547	90	991	1,172	4,519
1910	372	403	331	149	135	1,390
1911	1,139	639	31	560	828	3,197
1912	1,055	703	466	1,043	914	4,181
1913	1,963	1,128	754	1,629	2,390	7,864
1914	161	447	57	329	458	1,452
1915	2,398	1,984	400	1,311	2,066	8,159
1916	566	535	293	821	595	2,810
1917	1,942	1,455	345	802	1,045	5,589
1918	9	39	453	209	25	735
1919	2,839	922	1,057	722	753	6,293
1920	1,190	407	729	98	151	2,575

Baldwin.

	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Totals.
Before 1902	151	43	3	46	475	718
1902	43	207	0	114	548	912
1903	1,043	705	55	228	1,400	3,431
1904	231	18	51	98	577	975
1905	1,024	277	43	165	474	1,983
1906	4	128	33	26	634	825
1907	1,718	1,102	189	561	2,514	6,084
1908	110	106	88	25	280	609
1909	2,590	695	132	682	2,443	6,542
1910	41	469	8	22	121	661
1911	1,213	405	133	392	1,470	3,613
1912	683	1,264	205	537	1,176	3,865
1913	2,546	655	663	514	2,017	6,395
1914	371	820	36	690	765	2,682
1915	2,425	1,381	354	637	2,389	7,186
1916	333	910	99	479	1,178	2,999
1917	2,125	1,145	412	695	1,694	6,071
1918	315	1,046	261	528	480	2,630
1919	3,430	2,040	1,425	1,148	2,835	10,878
1920	625	964	60	6	82	1,737

Gravenstein.

	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Totals.
Before 1902	75	15	27	51	43	211
1902	196	3	65	91	57	412
1903	884	531	110	518	347	2,390
1904	44	10	22	84	103	263
1905	225	231	201	614	365	1,636
1906[1]	–	–	–	–	–	–
1907	775	482	162	572	709	2,700
1908	265	347	189	431	184	1,416
1909	1,180	284	224	1,217	1,192	4,097
1910	50	514	199	41	27	831
1911	612	282	291	793	1,008	2,986
1912	24	402	377	25	50	878
1913	1,922	976	897	2,736	1,474	8,005
1914[1]	–	–	–	–	–	–
1915	694	1,472	778	1,685	1,149	5,778
1916	16	199	79	54	50	398
1917	479	1,475	1,223	1,432	1,036	5,645
1918	37	53	209	26	39	364
1919	370	1,054	979	912	1,012	4,327
1920	297	224	747	305	365	1,938

[1] No crop.

Table III. — *Graves Orchard: Trunk Circumferences of Individual Trees (Inches).*

	Plot 1.		Plot 2.		Plot 3.		Plot 4.		Plot 5.		Plot 6.		Plot 7.		Plot 8.	
Row.	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1908		6.3	10.0	8.0	14.5	11.5	9.5	11.0	12.0	17.0		10.0	10.0			
1913		11.0	19.5	16.5	22.3	19.8	17.8	18.8	20.5	29.6		17.3	17.0			
1915		13.8	23.5	20.5	24.5	23.0	22.5	22.0	23.8	33.5		17.8	19.0			
1917		16.8	25.8	24.0	25.5	25.0	26.5	24.0	25.5	36.0		19.5	20.5			
1921			32.0	30.5	31.5	30.8	30.8	28.5	33.0	44.0		24.5	24.8			
1908	6.0	9.0	7.3	14.0	14.0											
1913	14.8	18.0	18.1	27.9	24.9											
1915	19.0	21.5	22.5	31.5	27.5											
1917	23.5	24.5	25.8	34.0	30.0											
1921	29.5	30.0	33.0	38.5	36.0											
1908	10.0		14.0	15.0		12.5	13.5	15.0	2.8		11.5	13.0	14.5			10.0
1913	20.5		28.3	29.1		22.8	30.0	29.4	9.0		22.6	19.8	24.4			17.5
1915	24.8		32.0	33.5		25.8	33.3	33.0	13.5		27.5	21.3	26.5			
1917	28.0		34.0	35.5		28.0	37.5	36.0	18.3		30.0	23.5	29.0			23.0
1921	31.8		39.0	41.3		33.5	42.3	41.8	24.5		37.0	28.3	32.3			29.8
1908			11.5	8.0	12.5	11.5	12.0	11.0		10.0	17.0	10.0	18.0	11.0	17.0	11.0
1913			24.0	18.3	25.9	19.3	21.5	18.8		20.8	27.4	17.8	27.1	19.8	32.5	22.0
1915			28.0	22.0	28.8	21.0	24.8	21.5		24.0	30.8	20.0	30.5	22.8	37.5	26.5
1917			31.0	25.0	31.0	23.0	27.5	23.5		27.0	34.0	22.8	33.0	25.0	40.0	30.5
1921			37.0	29.5	37.5	27.5	31.3	27.8		30.5	40.0	27.0	37.5	31.5	48.8	37.0
1908		13.0	11.5	14.5	14.5	11.5	15.0	13.5	13.0	10.5	15.5	18.0	16.0	17.0		11.0
1913		25.3	26.1	29.0	26.5	16.3	25.1	25.0	22.0	20.9	28.4	31.0	28.8	28.8		23.5
1915		30.0	30.5	31.8	29.5	17.5	29.0	29.8	25.8	25.0	32.0	33.3	31.8	32.0		27.8
1917		32.8	33.3	34.0	31.0	18.3	32.0	32.0	28.3	26.5	34.0	37.5	34.0	34.5		30.5
1921		39.8	38.0	39.8	37.8	20.5	37.8	37.5	32.0	31.5	40.3	42.8	40.5	40.0		38.3
1908	8.8	11.0	9.0	13.0	13.0	10.0	12.0	15.0		17.0	12.5	16.0	16.0		15.5	8.5
1913	18.0	24.0	19.4	23.8	25.5	15.5	20.0	24.6		31.0	21.4	28.5	27.8		27.0	13.5
1915	22.3	28.5	22.0	27.3	28.3	16.0	23.5	28.0		35.8	23.0	31.5	31.3		31.3	16.0
1917	25.5	32.0	24.3	28.3	31.5	17.8	24.8	30.0		38.8	25.0	35.5	33.0		35.5	18.5
1921	31.5	38.8	30.0	32.5	37.5	19.8	29.5	36.5		47.0	30.3	39.5	39.8		40.5	24.3
1908		11.0	12.0		13.5	12.0	15.0	14.5	14.0	17.5	17.0	15.5	13.5		13.5	13.5
1913		23.0	23.1		24.1	21.0	21.9	25.8	21.3	29.8	29.0	23.0	21.5		25.1	22.4
1915		28.3	26.8		29.0	23.5	24.0	29.5	24.5	34.0	31.8	24.8	23.3		30.5	25.0
1917		31.8	29.5		32.0	24.0	25.0	32.3	26.5	37.0	35.0	26.0	25.0		34.5	28.0
1921		37.5	35.0		38.3	30.0	28.8	38.0	31.3	42.0	39.8	31.0	27.8		39.5	34.3
1908			12.5	9.0	17.0	13.0	13.0	14.0	12.5	9.5	17.5	16.0	12.0	6.0	11.0	9.0
1913			22.3	17.8	28.0	23.6	23.5	23.8	21.0	17.3	30.5	26.5	19.5	8.9	24.1	18.6
1915			25.8	20.5	30.3	25.3	26.5	26.5	23.0	19.5	34.8	29.0	21.8	10.0	28.0	22.3
1917			28.0	23.5	31.0	27.0	28.5	29.0	24.5	21.0	37.3	31.8	23.8	10.8	31.0	26.0
1921			33.0	28.0		30.8	31.3	35.5	27.5	27.5	43.0	38.0	27.3		37.0	32.5
1908		13.0		13.5	14.0	13.0	13.0	14.5	15.0	16.0	12.0	17.0	14.5			12.0
1913		25.0		25.0	21.0	19.0	24.5	22.9	27.1	27.6	28.9	28.5	25.0			24.0
1915		29.8		29.5	23.0	20.5	28.8	25.8	32.0	30.5	32.3	32.5	29.0			28.5
1917		31.5		33.0	25.0	22.0	30.5	28.8	35.0	32.0	34.5	35.5	31.0			32.0
1921		37.3		39.8	29.3	24.8	36.5	34.0	41.3	38.0	39.5	41.8	36.0			38.8
1908		13.5	14.0		16.0	15.5	14.5		12.0	15.5	14.0	13.5	14.0	15.0	13.0	
1913		26.0	26.3		24.8	25.8	28.6		22.9	27.5	24.5	24.0	24.1	26.5	26.0	
1915		30.0	30.0		26.3	28.8	32.3		26.3	30.8	27.5	26.3	27.5	30.8	31.0	
1917		33.5	33.5		28.0	31.0	34.5		28.5	33.5	30.0	29.5	29.5	33.5	34.0	
1921		38.5	39.0		33.8	36.5	41.3		35.3	38.5	35.0	34.5	34.8	39.8	39.3	
1908	12.5	12.5	17.0	15.0	10.0	14.0	10.5	16.0	16.0	11.0	15.5	15.0	17.5			
1913	25.5	25.0	30.5	29.0	21.0	24.6	21.0	28.0	28.9	22.5	24.4	27.1	29.8			
1915	30.5	28.5	34.3	33.5	23.5	27.3	24.8	32.3	32.0	25.5	27.0	31.0	33.5			
1917	33.5	28.5	37.0	36.5	25.3	30.0	27.0	36.0	35.0	27.0	29.3	34.5	36.0			
1921	39.3	33.0	42.0	41.5	30.3	35.5	31.3	40.5	41.0	31.5	34.0	38.8	40.8			
1908	10.5	13.0	16.5	14.0	13.5	14.5	13.5	14.0	14.0	16.0	14.0	15.5	17.5	13.0	8.0	
1913	22.8	26.3	30.9	25.0	24.8	24.1	26.0	25.1	23.3	27.0	26.3	26.8	29.5	26.5	19.0	
1915	29.5	31.0	36.0	28.8	28.8	27.0	30.5	28.8	26.5	30.3	29.5	30.5	32.8	31.3	22.8	
1917	30.5	34.8	39.0	31.0	32.0	29.5	33.0	32.0	28.0	31.5	32.0	33.0	35.0	34.0	26.3	
1921	37.0	39.8	44.5	37.0	37.3	35.5	38.0	37.5	32.8	38.0	37.5	39.0	39.8	40.0	32.5	

TABLE III. — *Graves Orchard: Trunk Circumferences of Individual Trees (Inches)* — Concluded.

	PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
Row.	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1908	8.5	12.0	14.0	11.5	16.5	11.5	10.0	14.0	15.0	17.5	13.0	15.0	14.5			
1913	21.3	20.8	25.5	23.5	29.8	20.0	21.0	26.5	25.9	29.0	23.0	27.3	27.6			
1915	25.5	23.3	29.5	27.0	33.8	22.8	24.8	30.0	30.0	33.0	25.5	30.8	31.0			
1917	28.0	25.0	31.5	30.0	36.0	23.5	27.8	32.5	33.0	35.3	27.5	34.0	34.5			
1921	31.0	29.5	35.8	36.8	41.3	30.5	32.0	36.0	39.0	40.5	31.8	38.5	39.0			
1908	7.5	12.0	14.0		15.5	12.0	13.0	16.0	15.0	11.0	12.5	14.0	14.0			
1913	19.0	21.8	26.5		25.5	19.0	21.0	24.5	23.5	16.5	20.4	21.8	24.0			
1915	19.5	24.3	29.8		28.8	20.8	23.8	28.8	26.5	17.8	23.0	24.0	25.8			
1917	22.0	26.0	32.5		30.8	23.0	25.5	31.3	28.8	18.5	25.0	26.0	28.5			
1921	28.5	32.0	38.0		37.8	26.5	29.0	35.8	33.5	23.5	30.0	31.5	35.5			
1908			11.0	15.0	15.0	14.0	14.0		14.5	11.0	10.0	15.5	16.0			
1913			16.8	25.5	21.6	20.5	22.9		21.0	20.4	17.0	21.5	24.0			
1915			18.0	27.8	23.3	23.3	25.0		22.5	22.5	20.0	23.0	26.3			
1917			19.5	29.3	24.3	29.0	28.0		24.3	26.0	22.0	23.0	28.0			
1921			25.0	33.3	32.0	32.0	32.0		28.0	31.5	28.3	31.3	35.8			
1908		8.5	10.0	14.0	13.5	14.0	16.0	9.0	11.0	11.5		13.0	11.0			
1913		15.0	19.4	22.5	21.0	19.0	24.6	14.8	17.9	15.6		19.5	16.9			
1915		17.3	22.5	25.0	22.3	20.5	26.0	16.5	19.5	19.8		22.3	20.3			
1917		20.5	25.5	27.0	25.0	21.5	27.8	19.5	21.5	18.0		25.0	22.5			
1921		28.5	32.5	32.5	31.3	28.0	31.5	25.8	27.5			32.0	29.8			
1908	5.0				12.0	15.0	12.5	13.5	12.0							
1913	12.3				18.5	21.6	18.8	22.1	15.0							
1915	15.5				20.3	22.3	19.8	25.5	18.3							
1917	19.3				22.0	24.5	22.0	28.0	20.8							
1921	27.8				29.3	28.3	27.0	35.8	28.8							
1908		11.0	13.5	15.0	14.5											
1913		23.3	23.9	24.0	20.0											
1915		26.3	26.8	27.5	19.5											
1917		30.3	29.5	30.5	20.5											
1921		36.8	38.5	39.0	25.8											
1908	9.0															
1913	17.8															
1915	21.5															
1917	26.0															
1921	32.5															

TABLE IV. — *Graves Orchard: Yield of Baldwin Trees (Pounds).*

Plot.	Row.	Number of Trees.	1911.	1912.	1914.	1915.	1916.	1917.
1	1	9			1,215	1,114	3,040	1,056
	2	13			1,357	3,817	4,191	2,433
	Total	22	2,023	326				
2	1	16			4,000	3,866	5,780	2,736
	2	14			2,331	2,773	3,719	1,269
	Total	30	6,519	1,307				
3	1	17			2,380	3,993	2,294	4,549
	2	16			964	2,199	1,069	2,806
	Total	33	7,734	2,216				
4	1	16			801	6,154	3,230	4,569
	2	14			1,175	5,560	3,154	3,484
	Total	30	6,540	1,125				
5	1	14			3,410	2,237	4,796	1,121
	2	14			5,944	3,706	4,922	2,827
	Total	28	3,179	1,642				
6	1	13			6,073	1,974	4,886	2,294
	2	15			5,648	3,475	4,413	3,059
	Total	28	7,040	1,625				
7	1	15			5,697	4,076	3,183	1,624
	2	5			1,070	1,125	827	1,561
	Total	20	5,581	907				
8	1	6			3,213	1,230	3,868	1,114
	2	7			1,130	1,052	1,164	1,766
	Total	13	2,124	146				

TECHNICAL BULLETIN No. 5.

DEPARTMENT OF VETERINARY SCIENCE.

CONCERNING THE DIAGNOSIS OF BACTERIUM PULLORUM INFECTION IN THE DOMESTIC FOWL.

BY GEORGE EDWARD GAGE.

During the years 1916, 1917, 1919 and 1920 special studies have been conducted in this department concerning the diagnosis of *Bact. pullorum* infection in chicks and adult birds. The object in view has been to determine factors which aid in accuracy of diagnosis. Therefore the plan here is to set forth the data obtained which may be of some value in substantiating the work of others, and to add any data from experimental studies and routine which may assist those who have to do with the pullorum problem.

Among the points to be considered by the laboratory and field worker in the *Bact. pullorum* problem, the following are of interest: —

1. Are there a *Bacterium pullorum* A and a *Bacterium pullorum* B?
2. Can infections with *Bacterium pullorum* and *Bacterium sanguinarium* be differentiated?
3. Is *Bacterium sanguinarium* (fowl typhoid) widely distributed in Massachusetts?
4. Is it necessary to submit suspicious *Bacterium pullorum* cultures to biochemical tests before a diagnosis is justified?
5. Is either *Bacterium pullorum* or *Bacterium sanguinarium* related to the so-called "paralysis" so widely distributed at certain periods of the year in Massachusetts?
6. Is *Bacterium sanguinarium* of any significance as the cause of epidemic disease in very young chicks?
7. What is the present status of the specificity of the agglutination test as a means of control of *Bacterium pullorum* infection in young chicks?

Historical.

The presence of cholera-like or typhoid-like epidemics in domestic birds dates back many years, but careful study extends only from the last quarter of a century. For a most excellent historical résumé of these studies from 1789 to 1913, the reader is referred to Hadley (1).

Since 1913 several investigators have added much to our knowledge concerning the biology of *Bact. pullorum*. Smith and Ten Broeck (2),

carrying out five sets of experiments in which serum of rabbits immunized with heated cultures of human typhoid, fowl typhoid and *Bact. pullorum*, considered that the agglutination tests were sufficiently definite to enable them to group the fowl typhoid and pullorum types together, both demonstrating the same intimate relation to typhoid bacilli. Again, in another paper (3), these writers demonstrated that fowl typhoid has many diagnostic features in common with the human typhoid bacillus, namely, the behavior toward carbohydrates and the agglutination reactions.

Rettger and Koser (4) carried out agglutination tests using reacting sera from rabbits immunized by subcutaneous injections, first of killed suspensions and later of living suspensions of *Bact. pullorum* and *Bact. sanguinarium*. Five days after the injections of heated vaccine, the rabbits were bled and the agglutinative power of the sera tested against definite suspensions of both *Bact. pullorum* and *Bact. sanguinarium*. No difference in agglutination properties was manifested. Attempts were made to increase the agglutination titre by the injection of living organisms. The titre remained the same and no change in the agglutinative ability of the two sera was manifested. Although these organisms have several characters in common, and particularly the serological reactions, they constitute two separate and distinct types, each bearing a specific relationship to the disease with which it has been associated, namely, either bacillary white diarrhœa or fowl typhoid. Taylor (5) concludes from his studies on fowl typhoid that the lesions produced in fowls which are infected with *Bact. sanguinarium* resemble in many respects those produced by *Bact. pullorum*, but, although there is a still closer resemblance in the biological characters of the two organisms, there is enough difference to warrant the conclusion that they are distinctly different diseases. Ward and Gallagher (6), studying forty-seven birds for comparison of agglutination and intradermal tests on naturally infected birds, report the absolute failure of each test as judged by the other test and by an autopsy, findings being similar in amount. Field tests on two hundred and thirty-one birds made simultaneously with the agglutination test at thirty-eight hours failed to detect one case reported positive to the other test.

Pfeiler and Rehse (7) present the clearest description of an epidemic in fowls due to the fowl typhoid bacillus. The fermentative reaction showed the organism to be similar to the human typhoid bacillus. According to Goldberg (8) the principal differences between the strains of *Bact. pullorum* and *Bact. sanguinarium* studied lie in the fact that *Bact. pullorum* produces gas in various carbohydrates while *Bact. sanguinarium* lacks this power in any of the carbohydrates he used, which included sugar-free media containing dextrose, lactose, saccharose, mannite, dextrine, inuline, galactose, levulose, raffinose, amygdalin, arabinose, adonite, dulcite, xylose, salicin, isodulcite, mannose, starch, glycerine, erythrol. The difference in gas production, as well as in their actions on milk, maltose, dulcite, dextrine, and isodulcite seems to indicate that these two organisms are distinct species of bacteria.

Hadley (1) concludes from his studies on the colon-typhoid intermediates that in carbohydrate media used known types of *Bact. pullorum*, *B. gallinarum*, *B. avisepticus*, *B. paratyphosus* A and B, manifest definite fermentative differences which justify regarding them as distinct species. Since paratyphoid A does not ferment xylose, a close relationship is shown between the types from poultry (pullorum and gallinarum) and paratyphoid B. The data presented indicate that pullorum is much less active than gallinarum on xylose. Aside from gas production there is a closer fermentative relation between *B. gallinarum* and the paratyphoids than between *Bact. pullorum* and the paratyphoids; this is due to the fact that pullorum is maltose-dextrine-dulcite negative. Hadley also finds that all the maltose-dextrine-dulcite negative strains isolated from chicks have been aerogenic, while all of the maltose-dextrine-dulcite negative strains isolated from adult birds were anaerogenic. The author has been able to isolate from the eggs of fowls experiencing infections with the maltose-dextrine-dulcite negative anaerogenic strains both aerogenic and anaerogenic forms. The gas production may vary quantitatively within wide limits. The writer has found that no one of the many original aerogenic pullorum strains, cultivated for years in artificial media, has lost its aerogenic power when placed under favorable conditions for growth; and none (either pullorum or gallinarum) that originally lacked this power ever attained it. According to these data one may conclude that if a strain, possessing otherwise the characteristics of pullorum or of gallinarum, is aerogenic it is not *B. gallinarum*, while if it is anaerogenic it may be either *Bact. pullorum* B or *B. gallinarum*. This indicates that it is necessary to make use of the maltose-dextrine-dulcite fermentation tests only when the strain in question is anaerogenic. In another paper (9) this same author concludes from his data that gas production by *Bact. pullorum* may depend upon whether the cultures are grown in glucose extract or glucose infusion broth. Propagating cultures for many years on artificial media does not cause them to lose their gas-producing ability. *Bact. pullorum* isolated from epidemics of bacillary white diarrhœa in young chicks or from infected eggs is aerogenic; there exist also anaerogenic strains which, in all the cases in which they have been observed, have been isolated from adult fowls experiencing acute or subacute infections simulating fowl typhoid in both clinical symptoms and pathological alterations of tissues. Therefore the writer proposes tentatively to postulate for *Bact. pullorum:* (1) *Bact. pullorum* A, aerogenic; and *Bact. pullorum* B, anaerogenic, pathogenic for adult stock only.

Hadley (10) suggests that *Bact. pullorum* appears to stand as a borderline group in the colon-typhoid intermediates, separating the actual paratyphoids from the actual paracolons; and further suggests that, in order to facilitate bringing about some degree of order in the group of colon-typhoid intermediates, gas-forming strains be referred to the paracolon group which should be revived; and that anaerogenic forms only be referred to the paratyphoid group, in which *B. gallinarum* (Klein) might stand as the type species.

Rettger and Koser (4) present data which indicate that dextrine, maltose and dulcite are attacked by *Bact. sanguinarium* with the production of acid but no gas. *Bact. pullorum* produces, on the other hand, no visible change of media containing these agents except slight alkali production. *Bact. pullorum* acts upon dextrose and mannite with evolution of appreciable amounts of gas, while *Bact. sanguinarium*, whether recently isolated or artificially cultivated for many years, does not produce gas in any of the carbohydrate media. Prolonged cultivation of *Bact. pullorum* in the laboratory does not cause this organism to lose its power of producing gas in dextrose and mannite broth. These authors conclude that *Bact. pullorum* manifests itself only as the cause of natural epidemic infection in young chicks. They further maintain that *Bact. sanguinarium* attacks fowls of different ages, and is of relatively little, if indeed any, significance as the cause of epidemic disease in very young chicks.

Mulsow (11) concludes from his studies that *B. avisepticus* may generally be distinguished from *Bact. sanguinarium* by its action in milk, indol production, fermentation of carbohydrates, agglutination reaction and pathogenesis. *Bact. pullorum* and *Bact. sanguinarium* do not produce indol, generally form hydrogen sulphid in lead acetate medium, and produce a temporary acidity in milk, but later alkalinity. As regards fermentation, *Bact. pullorum* produces acid and generally gas in the same carbohydrates, and in addition produces acid in dulcite and maltose. According to this author, *Bact. pullorum* may be distinguished from *Bact. sanguinarium* by the inability of the former to ferment dulcite, while the latter ferments this carbohydrate. *Bact. sanguinarium* generally produces acid promptly in maltose, and does not produce gas in any of the carbohydrates. Rhamnose is fermented promptly by *Bact. pullorum*, while *Bact. sanguinarium* produces acid only after forty-eight hours' incubation. It appears that there are sufficient differences, reported in this paper by Mulsow, between *Bact. sanguinarium* and *Bact. pullorum* to regard these as separate types.

Krumwiede and Kohn (12) report results which indicate that the essential characteristic of the paratyphoid-enteritidis group is the ability of its members to produce acid from rhamnose, differentiating both the aerogenic and anaerogenic members from *B. typhosus*. They point out that, without due regard to low and latent avidity for carbohydrates in relation to variability and practical differentiation, erroneous differential significance might easily be given to variation even among members of the fixed groups.

Experimental.

In the experiments presented, a study has been made of 112 different strains of *Bact. pullorum* isolated from diseased materials from poultry plants in various parts of Massachusetts, to determine, if possible, biochemical and cultural details which are constant enough to warrant their recommendation as a part of the procedure in diagnosis. The following organisms, listed in Table 1, have been isolated from cases of chick disease,

clinically white diarrhœa, and these conformed morphologically, biochemically and serologically to this group of organisms. It was further decided to study the uniformity of these 112 cultures biochemically and serologically, and to determine how many of them gave reactions which were similar to the reactions of its close relative, the fowl typhoid organism (*Bact. sanguinarium*). The cultures of *Bact. sanguinarium* were isolated from birds sent here for diagnosis, and the Smith, Cornell and Gage strains. There were five strains in this list. The two other than the three mentioned appeared typical of sanguinarium, were isolated during the early part of 1920, and designated the Humphrey and Massachusetts strains, respectively.

The following table lists the cultures of *Bact. pullorum* isolated and studied during the course of this work: —

Table 1. — *Strains of Bacterium Pullorum studied in this Investigation.*

Bacterium Pullorum.	Source of Culture.	When Isolated and Studied.
Strain No. 1 . . .	M. A. C. Amherst, Mass. Isolated March, 1914, from M. A. C. chick. Used in summer of 1914 as Strain A.	March, 1914
Strain No. 2 . . .	Experimental material from this laboratory. From unabsorbed yolk of chick inoculated summer of 1913 with S_3 (S_3 from Cutler egg). Used in summer of 1914 as Strain B.	
Strain No. 3 . . .	Isolated from material sent to laboratory. Used as Strain C in summer of 1914.	
Strain No. 4 . . .	Bridgewater, Mass. Isolated from Cutler chick. Used as S_2 in 1913. Used as Strain D in 1914.	
Strain No. 5 . . .	Maryland. Used at Maryland Experiment Station in 1911.	
Strain No. 6 . . .	Sterling, Mass. Isolated 1914. Trask Strain. Used as Strain F in summer of 1914.	May 1, 1914
Strain No. 7 . . .	Holliston, Mass. Isolated from chicks sent by C. E. Cristman, Silverwood Farm, Holliston, Mass. These chicks were bought of A. B. H. Arnold, Holliston, Mass.	Feb. 20, 1915
Strain No. 8 . . .	M. A. C. Amherst, Mass. No. 231 (2703) from unabsorbed yolk (chick).	Mar. 31, 1915
Strain No. 9 . . .	Holliston, Mass. Isolated from unabsorbed yolk of chick. Isolated from liver of chick.	
Strain No. 10 . . .	Northborough, Mass. Isolated from liver of chick .	Apr. 1, 1915
Strain No. 11 . . .	Franklin, Mass. 11–1 isolated from unabsorbed yolk of chick No. 2; 11–2 isolated from liver of chick No. 5.	
Strain No. 12 . . .	North Hadley, Mass. 12–1 from unabsorbed yolk of chick No. 1; 12–2 from unabsorbed yolk of chick No. 4; 12–3 from unabsorbed yolk of chick No. 9.	Apr. 5, 1915
Strain No. 13 . . .	Kingston, Mass. Isolated from unabsorbed yolk of chick No. 2.	Apr. 5, 1915
Strain No. 14 . . .	Center Marshfield, Mass. Isolated from unabsorbed yolk of chick No. 4.	Apr. 6, 1915
Strain No. 15 . . .	Brookline, Mass. Isolated from unabsorbed yolk of chick No. 1.	Apr. 7, 1915
Strain No. 16 . . .	Amherst, Mass. Isolated from liver of chick No. 1; 16–2 isolated from unabsorbed yolk of chick No. 1; 16–3 isolated from liver of chick No. 2.	Apr. 12, 1915
Strain No. 17 . . .	Southborough, Mass. 17–1 isolated from liver of chick No. 1; 17–2 isolated from heart of chick No. 2; 17–3 isolated from heart of chick No. 3; 17–4 isolated from unabsorbed yolk of chick No. 4; 17–5 isolated from unabsorbed yolk of chick No. 5; 17–6 isolated from unabsorbed yolk of chick No. 6.	Apr. 16, 1915
Strain No. 18 . . .	Littleton, Mass. 18–1 isolated from heart of chick No. 1; 18–2 isolated from liver of chick No. 1.	Apr. 17, 1915
Strain No. 19 . . .	Andover, Mass. Isolated from unabsorbed yolk of chick No. 1.	Apr. 22, 1915

TABLE 1. — *Strains of Bacterium Pullorum studied in this Investigation* — Continued.

Bacterium Pullorum.	Source of Culture.	When Isolated and Studied.
Strain No. 20 . . .	Westborough, Mass. Isolated from unabsorbed yolk of chick No. 2.	Apr. 23, 1915
Strain No. 21 . . .	Amherst, Mass. Chicks hatched from eggs bought at Hickory Farm, Ludlow, Mass. 21–1 isolated from heart of chick; 21–2 isolated from liver of chick.	May 15, 1915
Strain No. 22 . . .	Shrewsbury, Mass. Isolated from unabsorbed yolk of chick No. 1.	May 13, 1915
Strain No. 23 . . .	Natick, Mass. Isolated from liver of chick No. 1 .	May 14, 1915
Strain No. 24 . . .	Lowell, Mass. 24–1 isolated from unabsorbed yolk of chick No. 1; 24–2 isolated from unabsorbed yolk of chick No. 2.	May 15, 1915
Strain No. 25 . . .	South Hadley, Mass. 25–1 isolated from liver of chick No. 1; 25–2 isolated from unabsorbed yolk of chick No. 2.	June 2, 1915
Strain No. 26 . . .	Amherst, Mass. 26–1 isolated from liver of chick No. 1; 26–2 isolated from liver of chick No. 2.	June 2, 1915
Strain No. 27 . . .	Dedham, Mass. 27–1 isolated from liver of chick No. 1; 27–2 isolated from liver of chick No. 2.	June 2, 1915
Strain No. 28 . . .	Belchertown, Mass. Isolated from liver and unabsorbed yolk of chick.	May 2, 1916
Strain No. 29 . . .	Nobscot, Mass. 29–1 isolated from liver and unabsorbed yolk of chick; 29–2 isolated from liver and unabsorbed yolk of chick; 29–3 isolated from liver and unabsorbed yolk of chick; 29–4 isolated from liver and unabsorbed yolk of chick.	July 28, 1916
Strain No. 30 . . .	Concord, Mass. 30–1 isolated from liver and unabsorbed yolk of chick; 30–2 isolated from liver and unabsorbed yolk of chick; 30–3 isolated from liver and unabsorbed yolk of chick; 30–4 isolated from liver and unabsorbed yolk of chick; 30–5 isolated from liver and unabsorbed yolk of chick; 30–6 isolated from liver and unabsorbed yolk of chick.	Mar. 24, 1916
Strain No. 31 . . .	Holliston, Mass. 31–1 isolated from unabsorbed yolk of chick; 31–2 isolated from liver of chick; 31–3 isolated from unabsorbed yolk of chick.	May 2, 1917
Strain No. 32 . . .	Shrewsbury, Mass. Isolated from unabsorbed yolk of chick.	Feb. 28, 1917
Strain No. 33 . . .	Morrisville, N. Y. 33–1 isolated from unabsorbed yolk of chick; 33–2 isolated from unabsorbed yolk of chick.	Mar. 28, 1917
Strain No. 34 . . .	Egypt, Mass. Isolated from unabsorbed yolk of chick.	Mar. 16, 1917
Strain No. 35 . . .	Plainville, Mass. Isolated from unabsorbed yolk of chick.	Apr. 15, 1917
Strain No. 36 . . .	Fitchburg, Mass. 36–1 isolated from liver of chick; 36–2 isolated from liver of chick.	Apr. 13, 1917
Strain No. 37 . . .	Lunenburg, Mass. Isolated from liver of chick; 37–2 isolated from liver of chick.	Apr. 13, 1917
Strain No. 38 . . .	Sutton, Mass. 38–1 isolated from unabsorbed yolk of chick; 38–2 isolated from liver of chick.	Apr. 13, 1917
Strain No. 39 . . .	Southborough, Mass. Isolated from liver of chick	Apr. 16, 1917
Strain No. 40 . . .	Cohasset, Mass. Isolated from unabsorbed yolk of chick.	Apr. 16, 1917
Strain No. 41 . . .	Amherst, Mass. 41–1 isolated from unabsorbed yolk of chick; 41–2 isolated from unabsorbed yolk of chick; 41–3 isolated from unabsorbed yolk of chick; 41–4 isolated from unabsorbed yolk of chick.	Apr. 15, 1917
Strain No. 42 . . .	Shirley, Mass. 42–1 isolated from unabsorbed yolk of chick; 48–2 isolated from unabsorbed yolk of chick.	Apr. 18, 1917
Strain No. 43 . . .	Middleton, Mass. 43–1 isolated from ovary of chick; 43-2 isolated from ovary of chick.	Apr. 21, 1917
Strain No. 44 . . .	Spencer, Mass. Isolated from liver of chick . .	May 2, 1917
Strain No. 45 . . .	Greenfield, Mass. 45–1 isolated from liver of chick; 45–2 isolated from liver of chick.	May 3, 1917
Strain No. 46 . . .	Winchendon, Mass. 46–1 isolated from liver of chick; 46–2 isolated from liver of chick.	May 8, 1917

TABLE 1. — *Strains of Bacterium Pullorum studied in this Investigation* — Continued.

Bacterium Pullorum.	Source of Culture.	When Isloated and Studied.
Strain No. 47 . . .	Pittsfield, Mass. Isolated from liver of chick . .	May 7, 1917
Strain No. 48 . . .	Peabody, Mass. 48-1 isolated from unabsorbed yolk of chick; 48-2 isolated from unabsorbed yolk of chick.	May 24, 1917
Strain No. 49 . . .	Weymouth, Mass. 49-1 isolated from unabsorbed yolk of chick; 49-2 isolated from unabsorbed yolk of chick; 49-3 isolated from unabsorbed yolk of chick; 49-4 isolated from unabsorbed yolk of chick.	Apr. 10, 1917
Strain No. 50 . . .	Westfield, Mass. Isolated from unabsorbed yolk of chick.	May 24, 1917
Strain No. 51 . . .	Methuen, Mass. Isolated from liver of chick . .	Mar. 7, 1920
Strain No. 52 . . .	Methuen, Mass. Isolated from unabsorbed yolk of chick.	Mar. 7, 1920
Strain No. 53 . . .	Methuen, Mass. Isolated from unabsorbed yolk of chick.	Mar. 7, 1920
Strain No. 54 . . .	Methuen, Mass. Isolated from heart of chick . .	Mar. 7, 1920
Strain No. 55 . . .	Webster, Mass. Isolated from unabsorbed yolk of chick.	Mar. 15, 1920
Strain No. 56 . . .	Webster, Mass. Isolated from heart of chick . .	Mar. 15, 1920
Strain No. 57 . . .	Webster, Mass. Isolated from unabsorbed yolk of chick.	Mar. 15, 1920
Strain No. 58 . . .	Andover, Mass. Isolated from unabsorbed yolk of chick.	Mar. 19, 1920
Strain No. 59 . . .	Andover, Mass. Isolated from liver of chick . .	Mar. 19, 1920
Strain No. 60 . . .	Natick, Mass. Isolated from unabsorbed yolk of chick.	Mar. 19, 1920
Strain No. 61 . . .	Natick, Mass. Isolated from unabsorbed yolk of chick.	Mar. 19, 1920
Strain No. 62 . . .	Natick, Mass. Isolated from heart of chick . .	Mar. 19, 1920
Strain No. 63 . . .	Natick, Mass. Isolated from unabsorbed yolk of chick.	Mar. 19, 1920
Strain No. 64 . . .	Hubbardston, Mass. Isolated from liver of chick .	Mar. 23, 1920
Strain No. 65 . . .	Hubbardston, Mass. Isolated from liver of chick .	Mar. 23, 1920
Strain No. 66 . . .	Hubbardston, Mass. Isolated from unabsorbed yolk of chick.	Mar. 23, 1920
Strain No. 67 . . .	Hubbardston, Mass. Isolated from liver of chick .	Mar. 23, 1920
Strain No. 68 . . .	Lexington, Mass. Isolated from heart of chick .	Apr. 8, 1920
Strain No. 69 . . .	Lexington, Mass. Isolated from liver of chick .	Apr. 8, 1920
Strain No. 70 . . .	Lexington, Mass. Isolated from liver of chick .	Apr. 8, 1920
Strain No. 71 . . .	Lexington, Mass. Isolated from heart of chick .	Apr. 8, 1920
Strain No. 72 . . .	Longmeadow, Mass. Isolated from liver of chick .	Apr. 3, 1920
Strain No. 73 . . .	Plymouth, Mass. Isolated from liver of chick .	Apr. 3, 1920
Strain No. 74 . . .	Essex, Mass. Isolated from heart of chick . .	Apr. 9, 1920
Strain No. 75 . . .	Worcester, Mass. Isolated from unabsorbed yolk of chick.	Apr. 9, 1920
Strain No. 76 . . .	Worcester, Mass. Isolated from unabsorbed yolk of chick.	Apr. 9, 1920
Strain No. 77 . . .	Belchertown, Mass. Isolated from unabsorbed yolk of chick.	Apr. 9, 1920
Strain No. 78 . . .	Bridgewater, Mass. Isolated from liver of chick .	Apr. 12, 1920
Strain No. 79 . . .	Bridgewater, Mass. Isolated from unabsorbed yolk of chick.	Apr. 12, 1920
Strain No. 80 . . .	Wellesley, Mass. Isolated from unabsorbed yolk of chick.	Apr. 14, 1920
Strain No. 81 . . .	East Braintree, Mass. Isolated from liver of chick	Apr. 14, 1920

Table 1. — *Strains of Bacterium Pullorum studied in this Investigation* — Concluded.

Bacterium Pullorum.	Source of Culture.	When Isolated and Studied.
Strain No. 82 . . .	M. A. C. Amherst, Mass. Isolated from liver of chick.	Apr. 20, 1920
Strain No. 83 . . .	M. A. C. Amherst, Mass. Isolated from unabsorbed yolk of chick.	Apr. 20, 1920
Strain No. 84 . . .	M. A. C. Amherst, Mass. Isolated from unabsorbed yolk of chick.	Apr. 20, 1920
Strain No. 85 . . .	Chester, Mass. Isolated from unabsorbed yolk of chick.	Apr. 21, 1920
Strain No. 86 . . .	Chester, Mass. Isolated from liver of chick . .	Apr. 21, 1920
Strain No. 87 . . .	Chester, Mass. Isolated from liver of chick . .	Apr. 21, 1920
Strain No. 88 . . .	Boston, Mass. Isolated from liver of chick . .	Apr. 21, 1920
Strain No. 89 . . .	Leominster, Mass. Isolated from liver of chick .	Apr. 21, 1920
Strain No. 90 . . .	Medway, Mass. Isolated from liver of chick . .	Apr. 27, 1920
Strain No. 91 . . .	Medway, Mass. Isolated from liver of chick . .	Apr. 27, 1920
Strain No. 92 . . .	Wakefield, Mass. Isolated from liver of chick . .	Apr. 27, 1920
Strain No. 93 . . .	Wakefield, Mass. Isolated from liver of chick .	Apr. 27, 1920
Strain No. 94 . . .	M. A. C. Amherst, Mass. Isolated from unabsorbed yolk of chick.	Apr. 27, 1920
Strain No. 95 . . .	M. A. C. Amherst, Mass. Isolated from liver of chick.	Apr. 27, 1920
Strain No. 96 . . .	Littleton, Mass. Isolated from heart of chick . .	Apr. 30, 1920
Strain No. 97 . . .	Bedford, Mass. Isolated from liver of chick . .	Apr. 30, 1920
Strain No. 98 . . .	Bedford, Mass. Isolated from liver of chick . .	Apr. 30, 1920
Strain No. 99 . . .	Worcester, Mass. Isolated from liver of chick . .	May 4, 1920
Strain No. 100 . . .	Worcester, Mass. Isolated from liver of chick . .	May 4, 1920
Strain No. 101 . . .	West Acton, Mass. Isolated from liver of chick .	May 7, 1920
Strain No. 102 . . .	West Acton, Mass. Isolated from liver of chick .	May 7, 1920
Strain No. 103 . . .	Woonsocket, R. I. Isolated from liver of chick .	May 11, 1920
Strain No. 104 . . .	Woonsocket, R. I. Isolated from liver of chick .	May 11, 1920
Strain No. 105 . . .	Woonsocket, R. I. Isolated from liver of chick .	May 11, 1920
Strain No. 106 . . .	Belchertown, Mass. Isolated from unabsorbed yolk of chick.	May 14, 1920
Strain No. 107 . . .	Segreganset, Mass. Isolated from liver of chick .	May 18, 1920
Strain No. 108 . . .	Waltham, Mass. Isolated from liver of chick . .	May 21, 1920
Strain No. 109 . . .	Charlemont, Mass. Isolated from unabsorbed yolk of chick.	May 28, 1920
Strain No. 110 . . .	Hampton Falls, N. H. Isolated from liver of chick	May 29, 1920
Strain No. 111 . . .	Southwick, Mass. Isolated from liver of chick .	May 19, 1920
Strain No. 112 . . .	Hudson, Mass. Isolated from unabsorbed yolk of chick.	June 3, 1920

Change of Reaction in Carbohydrate Media by the 112 Strains of Bacterium Pullorum.

The cultures of *Bact. pullorum* were grown in test tubes of uniform length and caliber and in standard beef extract bouillon containing 1 per cent of the carbohydrate. These results were somewhat lower than those obtained by Goldberg (8), who found by using infusion broth that the percentage was higher. According to Hadley (10), on an average 0.7 per cent more acid is produced in sugar-infusion broth than in sugar-extract broth. Two drops of a bouillon suspension of each strain were used as the inoculum for a test, triplicate titrations made, and the average percentage acidity noted at the end of the fifth day. It appeared from our work in relation to time of acid production that the maximum occurred between the fifth and tenth day. Therefore the tables and curves represent the amount of acid at the end of a five-day period, at 37.5° C., expressed in percentage normal acid. All titrations were made in the cold, using $\frac{N}{20}$ NaOH and $\frac{N}{20}$ HCl and phenolphthalein as the indicator. Gas production was determined in dextrose, galactose, mannite, levulose, arabinose, salicin, mannose, xylose, adonite, erythrol, saccharose, dulcite, dextrine, lactose, raffinose, inulin, maltose and glycerine. Durham double-barreled fermentation tubes were employed, and the percentage of gas in the inner tube read off on the Frost gasometer chart at the end of five days' incubation at 37.5° C.

Dextrose. — This sugar was fermented by all the 112 strains. The lowest amount of acidity was 0.6 per cent and the highest 1.8 per cent, the mean of 108 determinations being 1.4 per cent acid. Gas was produced in this carbohydrate by all strains, ranging in quantity from a bubble to 55 per cent, the average for all the 112 strains being 20 per cent.

Mannite. — The acid production in mannite was greater than in dextrose and much more variable. After five days' growth the 112 strains had produced an average of 1.0 per cent acidity. The exceptions to this average were strains 23, 46 and 72 which produced 2.0 per cent, 2.2 per cent, and 1.7 per cent, respectively. Gas was produced by all strains, ranging in quantity from 20 to 50 per cent, with an average for the 112 strains of 30 per cent.

Galactose. — This sugar was fermented by all strains, being very much like mannite and dextrose. The acidity ranged from 0.1 to 2.1 per cent, the average for all cultures being 0.9 per cent. There were four exceptions which make a wide variation in the curve, — strains 29, 33, 42 and 49, which produced 0.1, 1.9, 2.0 and 2.1 per cent, respectively.

Levulose. — This sugar was fermented easily by all strains of *Bact. pullorum*, and the changes in reaction here correspond with those in dextrose, mannite and galactose, the acidity ranging from 0.2 to 2.0 per cent, the average for the 112 strains being 0.9 per cent. The exceptions were strains 63, 72 and 73, which produced 2.0, 1.9 and 1.5 per cent acidity, respectively.

Arabinose. — All strains fermented this carbohydrate, the acidity ranging from 0.5 to 1.0 per cent, with an average for the 112 strains of 0.7 per cent. This carbohydrate was fermented in a very variable manner.

Salicin. — None of the 112 strains fermented salicin. On the fifth day there was marked alkaline reaction in some strains. The average acidity for the 112 strains was 0.1 per cent.

Mannose. — This sugar was fermented by all the strains. The minimum acidity by any strain was 0.6 and the maximum 1.3 per cent. The average for the 112 strains was 0.9 per cent acid.

Xylose. — This sugar was fermented by all the strains, but none produced marked quantities of acid. The minimum produced by any strain was 0.1 and the maximum 0.4 per cent, with a mean of 0.25 per cent for the 112 strains. Therefore it may be said that these pullorum strains are not strongly xylose positive.

Adonite. — For the most part the initial acidity was not greatly changed. The minimum figure observed was an alkalinity of 0.1 per cent and the maximum an acidity of 0.1 per cent. As a group these strains were adonite-negative, the curve of results from the 112 strains running close to the line of initial acidity.

Erythrol. — This carbohydrate was not fermented significantly by any of the cultures of *Bact. pullorum* studied. All strains gave a reduction of the initial acidity. The acidity ranged from a minimum of —0.4 per cent to a figure which represented no change from original acidity. Therefore these 112 strains are erythrol negative.

Saccharose. — There was no appreciable amount of acid produced in this carbohydrate. The minimum reading was —0.2 per cent and a few readings showed no change from the initial acidity. The average acidity determination for the 112 strains was —0.2 per cent. There were two exceptions, strains 67 and 84, which showed a determination of —0.4 and —0.5 per cent for acidity. Therefore in saccharose there is no acid formed by *Bact. pullorum.*

Dulcite. — All the 112 strains of *Bact. pullorum* showed a marked reduction of acidity. A few strains did not change the initial acidity, the range being between no change of acidity and —0.4 per cent. There were three exceptions, however, cultures 32, 46 and 47, which produced the following results: —0.6, —0.5 and —0.5 per cent, respectively. Therefore it may be said that the results from these determinations indicate that *Bact. pullorum* is dulcite negative.

Dextrine. — The initial acidity was readily reduced by all strains studied. The readings ranged from no change in acidity to —0.3 per cent. There were no exceptions, all cultures demonstrating this reduction.

Lactose. — The initial acidity was reduced by all strains. The readings ranged from no change in acidity to —0.4 per cent, the mean reading being —0.12 per cent. *Bact. pullorum* may be considered, consequently, lactose-negative as regards acid production. Two strains, 93 and 109, were unusually prompt in this particular. Both strains gave a reading of —0.4.

Raffinose. — The acidity was reduced by all the pullorum strains. The average reading for the 112 cultures was —0.2 per cent. Strain 48 was capable of greater alkaline production than the others, giving a result of —0.5 per cent.

Inulin. — All strains of *Bact. pullorum* were negative in this carbohydrate, the mean reading being —0.19 per cent. There was a prompt reduction in initial acidity, only one culture of the 112 showing no change in the initial acidity.

Maltose. — None of the 112 strains produced any acid. The change was usually marked in all tubes on the fifth day. There was an average reduction of acidity of —0.18 per cent.

Glycerine. — None of the 112 strains produced any acid in glycerine. The determination on the fifth day showed a reduction in the final acidity, averaging —0.1 per cent.

Conclusions from the Fermentation Tests.

From the tests reported concerning the fermentation of the 112 strains of *Bact. pullorum*, it appears that this organism is positive in dextrose, galactose, mannose, mannite, levulose, xylose and arabinose; and negative in glycerine, maltose, adonite, dulcite, lactose, dextrine, saccharose, inulin, erythrol and raffinose. In salicin there is a slight indication of fermentation, at least a slight acidity in a large percentage of the strains. All strains of this organism studied showed a marked tendency to produce gas in

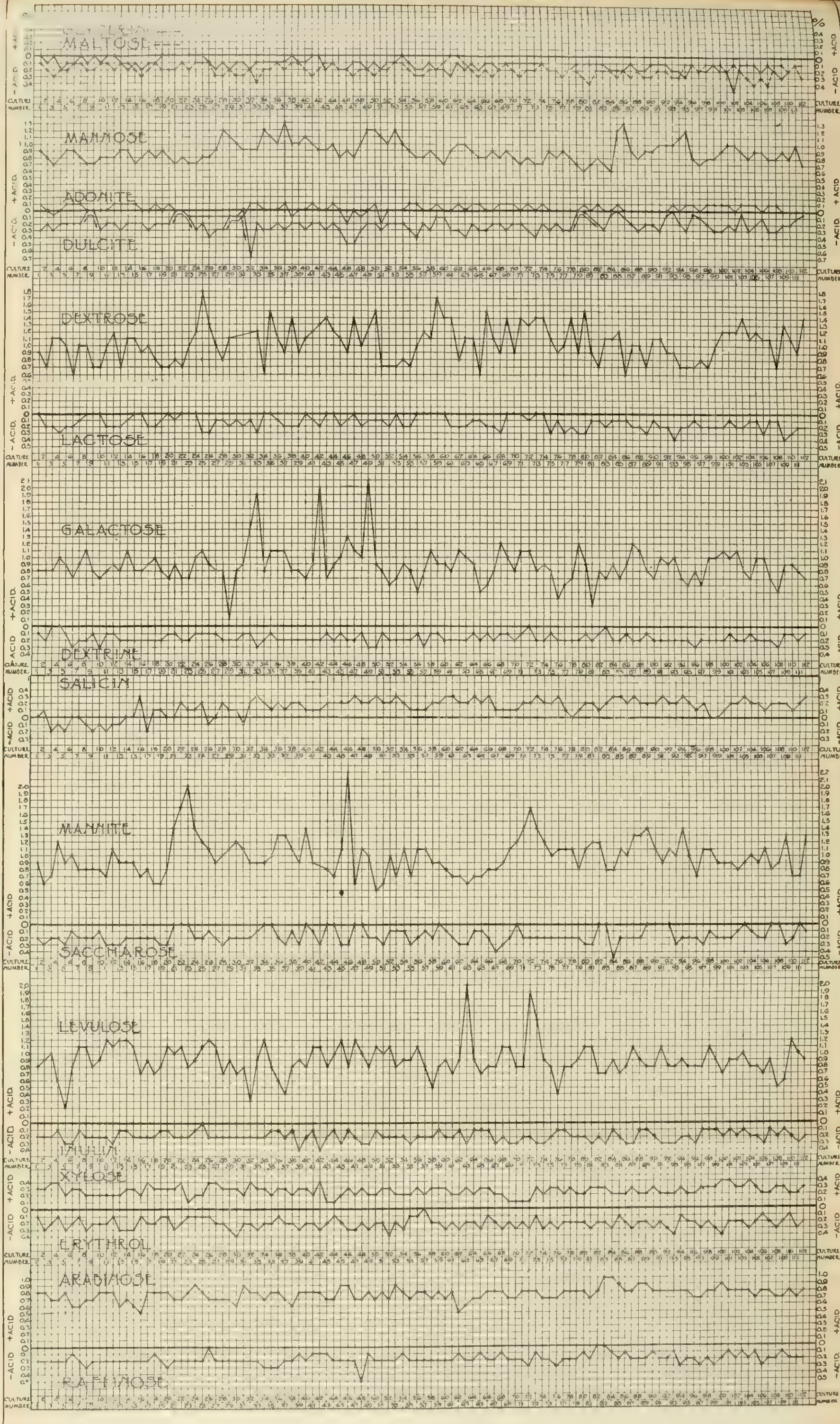

FIG. 1.—Curves showing change of reaction in carbohydrate media by 112 different cultures of *Bact. pullorum*. Percentage of acid produced at end of five-day period. Titration of 5 c.c. samples in the cold, using $\frac{N}{20}$ NaOH and $\frac{N}{20}$ HCl

dextrose. This aerogenic property of the pullorum strains is persistent. Cultures of pullorum carried for fourteen months in France during the war, and kept under adverse conditions, when planted again under favorable conditions regained their aerogenic properties, and the activities in this direction were as marked as in the original cultures. The 112 strains of *Bact. pullorum* studied, even after being transferred eighteen times, still retain active gas production in dextrose and mannite. In one exception, culture No. 44, there has never developed more than a bubble of gas in the dextrose. This is recorded in the table in the dextrose column as B, meaning bubble. All strains are methyl red negative. Therefore from previous morphological and cultural tests, linked with these biochemical findings, it may be concluded that the organism classed to-day as *Bact. pullorum* A should be a slender, non-motile, non-liquefying, gram-negative bacillus. It does not coagulate or peptonize milk. It produces gas in dextrose and mannite, forms H_2S in lead acetate medium, does not produce indol, and does not reduce nitrates.

Fermentation Tests with Bacterium Sanguinarium.

Dextrose. — This sugar was fermented by all the five strains, 0.8 per cent being the highest amount and 0.7 per cent the lowest, the mean being 0.7 per cent.

Mannite. — All cultures of *Bact. sanguinarium* produced about the same quantity of acidity, 0.8 per cent.

Galactose. — Fermented by *Bact. sanguinarium*, the percentage acidity being 0.7, 0.7, 0.6, 0.8 and 0.7 per cent, respectively.

Levulose. — Fermented more variably than galactose, 0.6 per cent being the lowest figure, and 0.9 per cent the highest.

Arabinose. — All strains fermented this carbohydrate, the readings being between 0.6 and 0.8 per cent acid.

Salicin. — Not fermented by the five strains.

Mannose. — This carbohydrate was fermented by *Bact. sanguinarium* about the same as mannite.

Xylose. — Fermented less actively in this carbohydrate, the readings being 0.5, 0.3, 0.2, 0.5 and 0.4 per cent acidity, respectively.

Adonite. — Not appreciably fermented by *Bact. sanguinarium.* The maximum figure obtained was 0.1 per cent acidity.

Erythrol. — Not fermented significantly by any of the five strains of *Bac. sanguinarium.*

Saccharose. — Not fermented by *Bact. sanguinarium.* There was increased alkalinity.

Dulcite. — In this carbohydrate the initial acidity was increased, 0.4 per cent being the maximum amount determined in any of the five cultures.

Dextrine. — There was a marked increase in acidity, four of the five strains of *Bact. sanguinarium* showing 0.6 per cent.

Lactose. — There was no increase in acidity by *Bact. sanguinarium.* There was a marked production of alkalinity.

Raffinose. — There was no increase in acidity in this carbohydrate; the initial acidity was markedly reduced.

Inulin. — There was no increase in acidity in this carbohydrate; the initial acidity was markedly reduced.

Maltose. — Large increase in acid was noted by all strains of *Bact. sanguinarium* in this carbohydrate.

Glycerine. — None of the strains of *Bact. sanguinarium* produced any acid in glycerine. The determination on the fifth day showed a reduction in initial acidity.

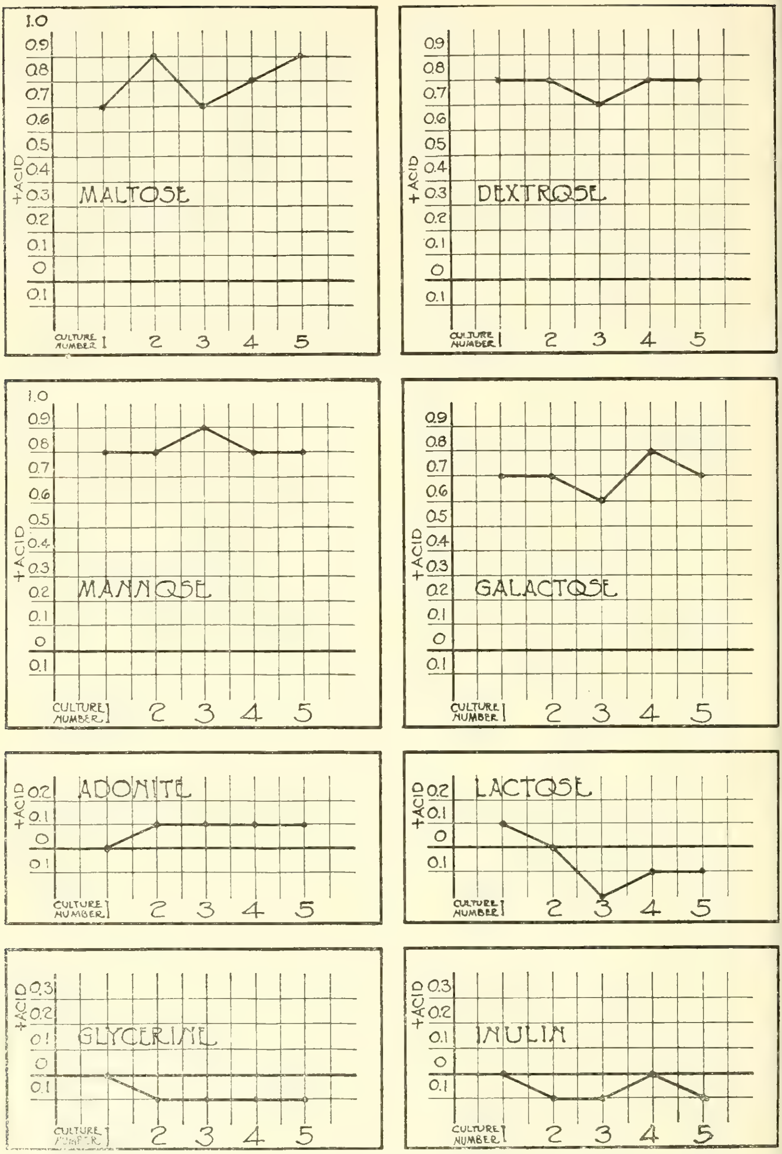

FIG. 2.—Curves showing change of reaction in carbohydrate media by cultures of *Bacterium sanguinarium*. Percentage of acid produced at end of five-day period. Titration of 5 c.c. samples in the cold, using $\frac{N}{20}$ NaOH and $\frac{N}{20}$ HCl.

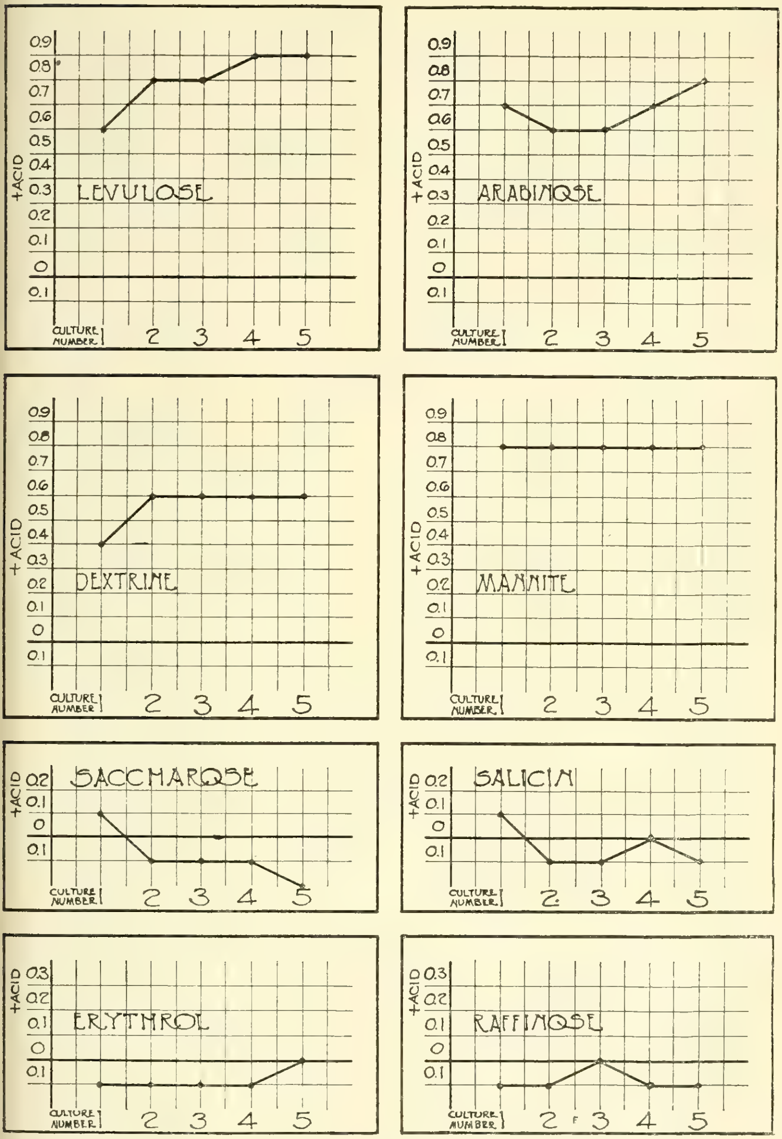

FIG. 2. — Curves showing change of reaction in carbohydrate media by cultures of *Bacterium sanguinarium* — *Continued.*

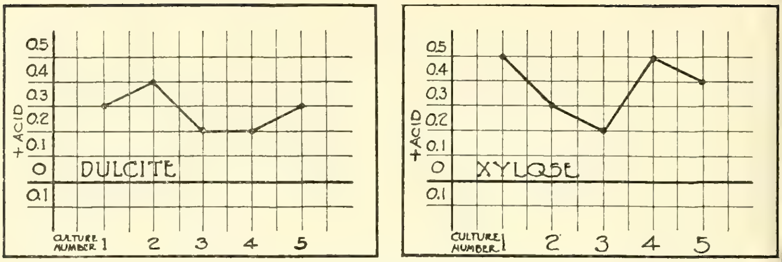

FIG. 2. — Curves showing change of reaction in carbohydrate media by cultures of *Bacterium sanguinarium* — *Concluded.*

TABLE 2. — *Gas Production of the 112 Strains of Bacterium pullorum in Carbohydrate Broth.*

[Percentage of gas in closed arm of fermentation tube.]

Culture Number.	Dextrose.	Mannite.	Galactose.	Levulose.	Arabinose.	Salicin.	Mannose.	Xylose.	Dulcite.	Culture Number.	Dextrose.	Mannite.	Galactose.	Levulose.	Arabinose.	Salicin.	Mannose.	Xylose.	Dulcite.
1	17	20	0	0	0	0	26	0	0	57	20	45	0	0	0	0	25	0	0
2	33	50	0	0	0	0	30	0	0	58	15	30	0	0	0	0	30	0	0
3	37	35	0	B	4	43	30	5	25	59	18	25	0	0	0	0	20	0	0
4	43	30	0	0	0	25	0	0	0	60	17	40	0	0	0	0	20	0	0
5	25	25	0	B	0	0	20	0	0	61	10	25	0	0	0	0	25	0	0
6	30	30	5	0	0	0	20	0	0	62	25	45	5	B	0	0	30	0	0
7	55	25	0	0	0	0	30	0	0	63	18	45	0	0	0	0	22	0	0
8	12	20	0	0	0	0	20	0	0	64	22	40	0	0	0	0	20	0	0
9	15	30	0	0	0	0	30	0	0	65	10	35	0	0	0	0	25	0	0
10	10	25	0	0	0	0	20	0	0	66	12	30	0	0	0	0	30	0	0
11	16	30	0	0	0	0	B	0	0	67	19	25	0	0	0	0	30	0	0
12	16	25	0	0	0	0	B	0	0	68	22	25	0	0	0	0	B	0	0
13	10	25	0	B	0	0	B	0	0	69	23	45	0	0	0	0	20	0	0
14	22	25	0	0	0	0	B	0	0	70	16	35	0	0	0	0	25	0	0
15	10	25	0	0	0	0	25	0	0	71	22	30	0	0	0	0	20	0	0
16	17	30	0	0	0	0	0	0	0	72	17	30	0	0	0	0	30	0	0
17	13	30	0	0	0	0	12	0	0	73	17	30	0	0	0	0	20	0	0
18	14	30	0	0	0	0	15	0	0	74	20	20	0	0	0	0	20	0	0
19	20	30	0	0	0	0	25	0	0	75	17	30	0	0	0	0	20	0	0
20	10	25	0	0	0	0	25	0	0	76	28	30	0	0	0	0	25	0	0
21	20	40	0	0	0	0	22	0	0	77	17	30	0	0	0	0	26	0	0
22	13	30	0	0	0	0	18	0	0	78	18	30	0	0	0	0	20	0	0
23	13	30	0	0	0	0	25	0	0	79	20	25	0	0	0	0	25	0	0

B—Bubble. 0—No gas.

Adonite, erythrol, saccharose, dextrine, lactose, raffinose, inulin, maltose and glycerine produced no gas with any of the cultures.

TABLE 2. — *Gas Production of the 112 Strains of Bacterium Pullorum in Carbohydrate Broth* — Concluded.

Culture Number.	Dextrose.	Mannite.	Galactose.	Levulose.	Arabinose.	Salicin.	Mannose.	Xylose.	Dulcite.	Culture Number.	Dextrose.	Mannite.	Galactose.	Levulose.	Arabinose.	Salicin.	Mannose.	Xylose.	Dulcite.
24 .	17	20	0	0	0	0	5	0	0	80 .	27	40	0	0	0	0	20	0	0
25 .	15	30	10	0	0	0	35	0	0	81 .	20	30	0	0	0	0	25	0	0
26 .	28	30	0	0	0	0	B	0	0	82 .	13	30	0	0	0	0	20	0	0
27 .	23	30	0	0	0	0	25	0	0	83 .	15	25	0	0	0	0	20	0	0
28 .	18	25	0	0	0	0	15	0	0	84 .	27	25	0	0	0	0	25	0	0
29 .	20	45	0	0	0	0	B	0	0	85 .	20	25	0	0	0	0	20	0	0
30 .	10	20	0	0	0	0	B	0	0	86 .	13	25	0	0	0	0	20	0	0
31 .	20	45	0	0	0	0	32	0	0	87 .	15	30	0	0	0	0	25	0	0
32 .	13	40	0	0	0	0	35	0	0	88 .	25	25	0	0	0	0	20	0	0
33 .	30	35	0	0	0	0	15	0	0	89 .	22	30	0	0	0	0	20	0	0
34 .	27	30	0	0	0	0	35	0	0	90 .	20	20	0	0	0	0	25	0	0
35 .	25	25	0	B	0	0	25	0	0	91 .	23	20	0	0	0	0	30	0	0
36 .	27	30	0	0	0	0	25	0	0	92 .	47	45	5	B	0	0	20	0	0
37 .	25	45	0	0	0	0	35	0	0	93 .	10	35	0	0	0	0	25	0	0
38 .	28	35	0	0	0	0	35	0	0	94 .	10	30	0	0	0	0	20	0	0
39 .	25	40	0	0	0	0	0	0	0	95 .	20	25	0	0	0	0	30	0	0
40 .	25	30	0	0	0	0	30	0	0	96 .	25	30	0	0	0	0	0	0	0
41 .	29	35	0	0	0	0	18	0	0	97 .	10	25	0	0	0	0	0	0	0
42 .	45	45	10	10	0	0	5	0	0	98 .	23	20	0	0	0	0	20	0	0
43 .	8	30	0	0	0	0	15	0	0	99 .	27	50	0	0	0	0	25	0	0
44 .	B	20	0	0	0	0	28	0	0	100 .	17	35	0	0	0	0	15	0	0
45 .	20	30	0	0	0	0	22	0	0	101 .	13	30	0	0	0	0	10	0	0
46 .	48	25	15	0	0	0	35	0	0	102 .	17	25	0	0	0	0	25	0	0
47 .	5	25	0	0	0	0	0	0	0	103 .	40	30	10	B	0	0	30	0	0
48 .	27	30	0	0	0	0	0	0	0	104 .	33	25	0	0	0	0	20	0	0
49 .	10	0	0	0	0	0	0	0	0	105 .	30	20	5	B	0	0	20	0	0
50 .	20	50	0	0	0	0	30	0	0	106 .	28	30	0	0	0	0	25	0	0
51 .	17	30	0	0	0	0	B	0	0	107 .	25	25	0	0	0	0	25	0	0
52 .	30	25	0	0	0	0	B	0	0	108 .	17	30	0	0	0	0	30	0	0
53 .	12	25	0	0	0	0	25	0	0	109 .	20	25	0	0	0	0	20	0	0
54 .	32	30	10	0	0	0	B	0	0	110 .	28	20	0	0	0	0	20	0	0
55 .	17	20	0	0	0	0	40	0	0	111 .	10	25	0	0	0	0	25	0	0
56 .	22	30	0	0	0	0	25	0	0	112 .	22	25	0	0	0	0	25	0	0

B=Bubble. 0=No gas.

Adonite, erythrol, saccharose, dextrine, lactose, raffinose, inulin, maltose and glycerine produced no gas with any of the cultures.

TABLE 3.—*Summary of Biochemical Data as Regards Fermentation of the 112 Strains of Bacterium Pullorum.*

[Acid[1] and gas[2] production.]

CULTURE	DEXTROSE		MANNITE		GALACTOSE		LEVULOSE		ARABINOSE		SALICIN		MANNOSE		XYLOSE		ADONITE		ERYTHROL		SACCHAROSE		DULCITE		DEXTRINE		LACTOSE		RAFFINOSE		INULIN		MALTOSE		GLYCERINE	
	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS	ACID	GAS
1	+	+	+	+	+	—	+	—	+	—	O	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	O	—
2	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	+	+	+	+	+	—	+	B	+	+	—	+	—	+	+	+	—	—	—	—	—	—	—	+	O	—	—	—	—	—	—	—	—	—	O	—
4	+	+	+	+	+	—	+	—	+	—	—	+	—	—	+	—	O	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—
5	+	+	+	+	+	—	+	B	+	—	—	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	+	+	+	+	+	+	+	—	+	—	O	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	+	+	+	+	+	—	+	—	+	—	O	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
8	+	+	+	+	+	—	+	—	+	—	—	—	—	+	+	—	O	—	—	—	—	—	O	—	—	—	O	—	—	—	—	—	—	—	—	—
9	+	+	+	+	+	—	+	—	+	—	—	—	—	+	+	—	O	—	—	—	—	—	O	—	—	—	O	—	—	—	—	—	—	—	O	—
10	+	+	+	+	+	—	+	—	+	—	—	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—
11	+	+	+	+	+	—	+	—	+	—	—	—	—	B	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
12	+	+	+	+	+	—	+	—	+	—	—	—	—	B	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
13	+	+	+	+	+	—	+	B	+	—	—	—	—	B	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	+	+	+	+	+	—	+	—	+	—	O	—	—	B	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	+	+	+	+	+	—	+	—	+	—	O	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	+	+	+	+	+	—	+	—	+	—	+	—	—	—	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17	+	+	+	+	+	—	+	—	+	—	—	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
20	+	+	+	+	+	—	+	—	+	—	O	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	O	—
21	+	+	+	+	+	—	+	—	+	—	O	—	—	+	+	—	O	—	—	—	O	—	O	—	—	—	—	—	—	—	—	—	—	—	O	—
22	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	O	—	O	—	—	—	O	—	—	—	—	—	—	—	O	—
23	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	—	—	—	—	O	—	—	—	—	—	O	—	—	—	—	—	—	—	O	—
24	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	O	—
25	+	+	+	+	+	+	+	—	+	—	+	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	O	—
26	+	+	+	+	+	—	+	—	+	—	—	—	—	B	+	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—
27	+	+	+	+	+	—	+	—	+	—	O	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
29	+	+	+	+	+	—	+	—	+	—	+	—	—	B	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30	+	+	+	+	+	—	+	—	+	—	+	—	—	B	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
31	+	+	+	+	+	—	+	—	+	—	—	—	—	+	+	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—
32	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
33	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
34	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	O	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—
35	+	+	+	+	+	—	+	B	+	—	+	—	—	+	+	—	O	—	—	—	O	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—
36	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
37	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
38	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
39	+	+	+	+	+	—	+	—	+	—	+	—	—	—	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
40	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	O	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—
41	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
42	+	+	+	+	+	+	+	+	+	—	+	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
43	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	O	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—
44	+	B	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	O	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—
45	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
46	+	+	+	+	+	+	+	—	+	—	+	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
47	+	+	+	+	+	—	+	—	+	—	+	—	—	—	+	—	O	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
48	+	+	+	+	+	—	+	—	+	—	+	—	—	—	+	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
49	+	+	+	+	+	—	+	—	+	—	+	—	—	—	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
50	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
51	+	+	+	+	+	—	+	—	+	—	+	—	—	B	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
52	+	+	+	+	+	—	+	—	+	—	+	—	—	B	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
53	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	O	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—
54	+	+	+	+	+	+	+	—	+	—	+	—	—	B	+	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—
55	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
56	+	+	+	+	+	—	+	—	+	—	+	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—

[1] + = acid production.
— = alkali production.
O = neutral.

[2] + = gas produced.
— = no gas produced.
B = bubble (not enough to measure).

TABLE 3. — *Summary of Biochemical Data as Regards Fermentation of the 112 Strains of Bacterium Pullorum* — Concluded.

[Acid[1] and gas[2] production.]

Culture	Dextrose		Mannite		Galactose		Levulose		Arabinose		Salicin		Mannose		Xylose		Adonite		Erythrol		Saccharose		Dulcite		Dextrine		Lactose		Raffinose		Inulin		Maltose		Glycerine	
	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas
57	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	O	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
58	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
59	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	O	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
60	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
61	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–	–
62	+	+	+	+	+	+	+	B	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–	–
63	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
65	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
66	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
67	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
68	+	+	+	+	+	–	+	–	+	–	+	–	+		+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
69	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
70	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	O	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
71	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
72	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–
73	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
74	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–
75	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
76	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
77	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
78	+	+	+	+	+	–	+	–	+	–	O	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
79	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–
80	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–
81	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
82	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	O	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–
83	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	O	–	–	–	O	–	–	–	O	–	–	–	–	–	–	–
84	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
85	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–
86	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
87	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
88	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
89	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
90	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
91	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
92	+	+	+	+	+	+	+	B	+	–	+	–	+	+	+	–	O	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
93	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–
94	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
95	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
96	+	+	+	+	+	–	+	–	+	–	+	–	+	–	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
97	+	+	+	+	+	–	+	–	+	–	+	–	+	–	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
98	+	+	+	+	+	–	+	–	+	–	O	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
99	+	+	+	+	+	–	+	–	+	–	O	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
100	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
101	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
102	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
103	+	+	+	+	+	+	+	B	+	–	+	–	+	+	+	–	+	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
104	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
105	+	+	+	+	+	+	+	B	+	–	+	–	+	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
106	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
107	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
108	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	+	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
109	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
110	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
111	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
112	+	+	+	+	+	–	+	–	+	–	+	–	+	+	+	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

[1] + = acid production.
— = alkali production.
O = neutral.

[2] + = gas produced.
— = no gas produced.
B = bubble (not enough to measure).

A comparison of the tables which have to do with *Bact. pullorum* with those which have to do with *Bact. sanguinarium* shows that *Bact. pullorum* is maltose-dextrine-dulcite negative, while *Bact. sanguinarium* is maltose-dextrine-dulcite positive. All freshly isolated strains of *Bact. pullorum* (139 strains) have produced gas, while the five strains of *Bact. sanguinarium* have never produced gas. The 112 strains of *Bact. pullorum* studied have been maltose-dextrine-dulcite negative. This agrees very well with the work of Hadley. Thus far we have isolated but one organism from chicks, showing typical symptoms of white diarrhœa, which did not produce gas in dextrose. This particular strain was maltose-dextrine-dulcite negative, and therefore would correspond to *Bact. pullorum* B or the anaerogenic pullorum form. During the current year, 1920–21, several anaerogenic forms have been isolated from adult hens, and they were maltose-dextrine-dulcite negative, which in a way helps to substantiate Hadley's claim that the *Bact. pullorum* infecting adult hens is maltose-dextrine-dulcite negative, but anaerogenic. The number of cases thus studied is meager, and future studies with more cases ought to give sufficient data to establish this point. Since Hadley has been able to isolate both aerogenic and anaerogenic forms of *Bact. pullorum* from the eggs of fowls experiencing infections with the maltose-dextrine-dulcite anaerogenic strains, and since the maltose-dextrine-dulcite negative strains isolated by him from chicks have been aerogenic, while all the maltose-dextrine-dulcite negative strains isolated from infections in adult birds have been anaerogenic, the duality of the *Bact. pullorum* type appears to be justified. The work presented in this paper substantiates Hadley's results. Besides, the gas production is of great value as a differential characteristic. Therefore it is essential in making a differential bacterial diagnosis for *Bact. pullorum* to note its special morphological characteristics; to ascertain its fermentation activities in maltose, dextrine and dulcite, and its aerogenicity. Doubtful cultures of *Bact. pullorum* should be submitted to the above biochemical tests before a differential diagnosis is justified. As a routine in this department, all doubtful cultures are tested for aerogenicity in dextrose, and for acidity in maltose; methyl red being used as an indicator for the increased acid production. The data at hand indicate that there are maltose-dextrine-dulcite negative strains which do not produce gas in dextrose, and these, whether found only in adult birds or not, should be classed as the *Bact. pullorum* B, different from the one so generally isolated from chicks, which is maltose-dextrine-dulcite negative, but produces gas in dextrose.

The fowl typhoid (*Bact. sanguinarium*) is characterized, aside from its specific morphology, as an anaerogenic non-motile bacillus. It does not form indol, nor reduce nitrates. It forms H_2S in lead acetate media. It is a maltose-dextrine-dulcite positive organism.

Distribution of Fowl Typhoid in Massachusetts.

During the seasons of 1919–20 and 1920–21, observations were made on all specimens sent to the laboratory for diagnosis, especially to note the presence of *Bact. sanguinarium*. During that time more than 600 different specimens were examined, and this anaerogenic, non-motile bacillus which was maltose-dextrine-dulcite positive was isolated but six times, — three times in the season of 1919–20 and three times in the season of 1920–21. These cases exhibited all the post-mortem findings peculiar to this disease. Especially noticeable were the enlarged spleen and the marked leukemic condition. There were, however, several maltose-dextrine-dulcite negative forms isolated which were anaerogenic, these classifying as *Bact. pullorum* B. During this same period 289 chicks, sent here with a history of bacillary white diarrhœa, were examined, and the true *Bact. pullorum* was isolated from all but one. This one strain was anaerogenic, and persistently gave a faint acid reaction in maltose when methyl red was used as an indicator. From this it would appear that in this one chick we were dealing with an organism which came close to the *Bact. sanguinarium* type. From these findings the writer is led to believe that the fowl typhoid infection in Massachusetts is infrequent, and that the *Bact. pullorum* B type is far from common. In our work of the last few years we have never isolated from eggs a *Bact. pullorum* form which was anaerogenic. All cultures have been aerogenic and have produced little or no acid in maltose, dextrine or dulcite.

Although this represents but two years' observations, there appears to be sufficient evidence to indicate that fowl typhoid is not widely distributed in Massachusetts; that it is not transmitted by the egg; and that *Bact. pullorum* of the B type is found frequently in adult stock.

Does either Bact. Pullorum or Bact. Sanguinarium play Any Part in the so-called "Paralysis" so widely distributed in Massachusetts?

During the course of the studies concerning the diagnosis of *Bact. pullorum*, there were brought to the laboratory many birds suffering with the so-called "paralysis," which even now is assuming a vast economic importance in the poultry industry in Massachusetts. The weakness of the legs and the listlessness of these birds were not essentially different from conditions produced in rabbits when inoculated with pure cultures of *Bact. pullorum*. With this in mind, all specimens exhibiting the paralytic symptoms were examined bacteriologically, with special reference to *Bact. pullorum* and *Bact. sanguinarium*. There were 83 paralytic specimens examined, and from 5 of them only was isolated *Bact. pullorum* of the aerogenic type. None of the 83 specimens exhibited the marked enlarged spleen and leukemic conditions found in fowl typhoid, as known to us in this laboratory. The anaerogenic maltose-dextrine-dulcite positive organism of fowl typhoid was not isolated from any of the 83 specimens. Cultural examinations were made of liver tissue, spleen, intestinal mucosa,

ovarian tissues, and lumbar region of the spinal cord. In this so-called "paralysis" all birds during life showed a rather bright red comb, the paleness being evident only a short time before death. There was never found at autopsy a marked leukemia. In fowl typhoid this leukemic condition is highly prominent, and for this reason Moore has called this paratyphoid type of infection "infectious leukemia." Hadley has observed a similar epidemic in fowls showing pronounced leukemic symptoms associated with *Bact. pullorum.* The writer has never observed this condition in relation to *Bact. pullorum* infections in adult birds.

From these observations on the 83 paralytic birds, with only 5 showing the presence of the *Bact. pullorum* infection, — these five probably having carried the infection since chickhood, — the evidence does not indicate that the paralytic disease so widely distributed at certain periods of the year in Massachusetts is due to the presence of either the pullorum or sanguinarium type.

Influence of Infection upon the Hatching Quality of Eggs and upon the Viability of Young Stock.

In 1917 and 1918 several sets of experiments were carried out under the best known conditions for poultry husbandry. Eggs from 60 hens known to have reacted positively to the agglutination test were set in an electrobator. When tested at the end of the first seven days of incubation, 30 were found to be infertile and 2 were found dead in the shell. Of the 28 left, 10 were hatched; 3 chicks died at the end of the first day and *Bact. pullorum* (aerogenic type) was isolated from the unabsorbed yolk. All eggs containing fully developed chicks were examined especially for *Bact. pullorum*, with the following results. The egg number in each case represents the number of the hen laying the egg.

TABLE 4. — *Results of Tests for Bacterium Pullorum in Dead Chicks from Eggs laid by Positively Reacting Birds.*

Egg Number.	Bact. pullorum.	Egg Number.	Bact. pullorum.
8001	+	7925	—
8384	+	7998	—
8388	—	8430	+
8002	—	8430	—
8002	—	8565	+
8430	+	8388	+
7925	—	7998	+
8565	—	8430	—
8001	+	8384	—

+=present. —=not present.

From this table it will be seen that with the methods used it was not possible to detect *Bact. pullorum* in all the dead chicks, although adult hens were all positively reacting to the agglutination test. From 8, *Bact. pullorum* was isolated without difficulty; from the other 10, the cultures were negative.

After three months, following out three sets of incubation, the author was able to obtain from the three sets of eggs set, 60 in each lot, all from positively reacting hens, 7 livable chicks on the first set, 9 on the second set, and 9 on the third set, and these chicks were all given the numbers of the parent stock from which they came: 7811, 7895, 7925, 7997, 7998, 8001, 8002, 8020, 8082, 8084, 8094, 8139, 8171, 8180, 8202, 8204, 8294, 8384, 8388, 8389, 8430, 8431, 8544, 8565, 8810. These 25 birds, all reared from positively agglutinating hens, were yarded together and blood taken at various times to determine whether their blood would show any signs of agglutinative powers.

When the chicks had grown to a weight of at least 400 grams, they were put together in the yard on Aug. 10, 1917. The following table shows the weight of each bird at that time: —

TABLE 5. — *Weight of Chicks on Aug. 10, 1917.*

CHICK NUMBER.	Weight (Grams).	CHICK NUMBER.	Weight (Grams.)
7811	870	8180	680
7895	1,200	8204	450
7925	1,240	8202	580
7997	860	8294	780
7998	1,249	8384	620
8001	1,160	8388	530
8002	1,130	8389	540
8020	680	8430	540
8082	950	8431	380
8084	1,490	8544	510
8094	730	8565	530
8139	1,050	8810	670
8171	780		

Agglutination tests were run on these birds, the first being on July 17, 1917. The following table shows the reactions for this and subsequent tests: —

TABLE 6. — *Records of Agglutination Tests on Chicks hatched from Eggs laid by Positively Reacting Hens.*[1]

Chick Number.	July 17 and 18, 1917. Dilution of serum.					July 21, 1917. Dilution of serum.					Aug. 3, 1917. Dilution of serum.					Aug. 26, 1917. Dilution of serum.					Nov. 7, 1917. Dilution of serum.				
	1–100.	1–200.	1–500.	1–1000.	1–2000.	1–100.	1–200.	1–500.	1–1000.	1–2000.	1–100.	1–200.	1–500.	1–1000.	1–2000.	1–100.	1–200.	1–500.	1–1000.	1–2000.	1–100.	1–200.	1–500.	1–1000.	1–2000.
7811	?	?	?	?	?	C	?	?	?	?	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
7895	?	?	?	?	?	0	0	0	0	0	C	C	C	0	0	?	?	?	?	?					
7925	0	0	0	0	0	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
7997	C	C	0	0	0	0	0	0	0	0	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
7998	0	0	0	0	0	0	0	0	0	0	C	C	0	0	0	?	?	?	?	?	?	?	?	?	?
8001	0	0	0	0	0	?	?	?	?	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8002	0	0	0	0	0	C	0	0	0	0	C	C	0	0	0	?	?	?	?	?	0	0	0	0	0
8020	0	0	0	0	0	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
8082	C	?	?	?	?	0	0	0	0	0	C	C	0	0	0	C	C	0	0	0					
8084	?	?	?	?	?	0	0	0	0	0	C	C	C	C	C	C	C	C	C	C	C	C	0	0	0
8094	0	0	0	0	0	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
8139	?	?	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8171	?	?	?	?	?	?	?	?	?	?	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
8180	C	C	C	C	C	C	C	C	C	C	C	0	0	0	0	C	C	C	0	0	C	C	C	C	C
8202	0	0	0	0	0	0	0	0	0	0						C	C	C	C	C	C	C	C	C	C
8204	?	?	?	0	0	C	C	C	C	?	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
8294						0	0	0	0	0	C	C	C	C	C	C	C	0	0	0	C	C	C	C	C
8384	C	C	C	C	C	0	0	0	0	0	C	0	0	0	0	C	C	C	0	0	C	C	C	C	C
8388	?	?	?	?	?	C	C	C	C	C	?	?	?	?	?	C	C	0	0	0	C	C	0	0	0
8430	?	?	?	0	0	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
8565	?	?	?	?	?	C	C	C	C	C	C	C	C	C	0	C	C	C	C	C	C	C	C	C	C
8810	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	?	?	?	?					

[1] The symbols indicating various degrees of agglutination have been taken from Hadley, Journal of Immunology, Vol. 2, p. 463, 1917, as follows: C=complete agglutination; ?=doubtful agglutination; 0=no agglutination.

These experiments indicate that in chicks hatched from eggs laid by positively reacting hens, at least six months' time should elapse before the normal agglutination power of such sera would be sufficiently definite to furnish indication of past or present infection. The birds reared from hens 8001, 8139 and 8810 never showed any agglutinative power to their blood sera. The length of time a serum maintains its agglutination power has not as yet been determined.

The Present Status of the Specificity of the Agglutination Test as a Means of Control of Bacterium Pullorum Infection in Young Chicks.

During the last few years the agglutination test has become a popular means of recognition in the domestic fowl of those individuals which have contracted *Bact. pullorum* infections in chickhood; and consequently, as adult productive fowls, may have become, through infections in their ovaries, carriers of infection to the offspring. Several writers have demonstrated that there are certain factors which have influenced the test and which suggest the need of modification of the method in the direction of securing a higher degree of specificity. Hadley suggests that we stand in need of a means of diagnosis which shall distinguish between a latent (presumably ovarian) and a past infection. The data presented up to date indicate that not all adult hens with *Bact. pullorum* have infections localized in the ovaries; and also that not all infection has its origin in an attack of bacillary white diarrhœa experienced in the chick stage. This point, as Hadley suggests, is of less significance in its bearing upon the validity of the results of agglutination tests for *Bact. pullorum* infection than is the question of the specificity of the test. This author as well as others has demonstrated the interagglutinability of *Bact. pullorum*, fowl typhoid and other antigens in both *Bact. pullorum* and fowl typhoid serum. Fowls which have been experimentally immunized against different types of fowl typhoid possess serum which agglutinates *Bact. pullorum* antigens quite as well as it agglutinates its homologous antigen. According to these data the agglutination test for the recognition of *Bact. pullorum* infection appears to lose some of its claim to specificity; and to this extent, without carefully going over the results as obtained in field and laboratory co-operating, it may be open to criticism.

If all operations both in field and laboratory are considered, however, the reader will be convinced that the test yields valuable results. From our work, already reported, during the seasons of 1919–20 and 1920–21, there were only six cases where the anaerogenic type of organism was isolated and the post-mortem examinations revealed the enlarged spleen associated with leukemic conditions. This indicates that, at least so far as this laboratory has been called upon to make examinations, fowl typhoid infections are infrequent. That all infections are localized in the ovary is yet to be proven. It can be said, however, that the ovarian infections are not rare, and when they are present they persist. During the course of the examination of hundreds of eggs for *Bact. pullorum* infection, only the true aerogenic form of *Bact. pullorum* was isolated. Strains of these cultures, even after four years, maintained this aerogenic property and were maltose-dextrine-dulcite negative. Therefore these studies indicate that fowl typhoid is not transmitted to the egg. In all of our work in the bacteriological examination of young chicks, in all cases showing large unabsorbed yolks, we have been able to isolate only the aerogenic type of organism, and this in hundreds of cases. This shows an apparent lack of

susceptibility of young stock to the *Bact. sanguinarium* type of infection, and appears to substantiate the work of Dr. Hadley, who states that he has examined large numbers of cultures derived from young stock, but has not encountered among them the *Bact. sanguinarium* type.

In this laboratory hundreds of agglutination tests have been made to demonstrate the interagglutinability of *Bact. pullorum* with *Bact. sanguinarium*, *B. typhosus*, *B. paratyphosus* A, and *B. paratyphosus* B. The results obtained here agree with those from other laboratories: *i.e.*, that the agglutinative tests are sufficiently definite for grouping the fowl typhoid and pullorum types together, both demonstrating the same intimate relation to typhoid bacilli. In every test made, the *Bact. pullorum* immune serum agglutinates typhoid antigen better than typhoid serum agglutinates pullorum antigen. *Bact. sanguinarium* immune serum agglutinates *Bact. pullorum* much better than it does typhoid. There has never been demonstrated any indication of an affinity of interagglutinability between *B. avisepticus* (fowl cholera) and the pullorum and sanguinarium types. While it is true that by our present methods it is difficult to differentiate sanguinarium and pullorum by agglutination, this does not mean that application of the test will not yield valuable results. Already, from the work of three years, the typical maltose-dextrine-dulcite positive anaerogenic fowl typhoid organism has been isolated six times, and in this study more than 600 specimens were examined. This indicates that fowl typhoid is not widespread, at least in Massachusetts.

From the preceding biochemical data the establishment of *Bact. pullorum* and *Bact. sanguinarium* as separate types is justifiable. Therefore if it can be proven that breeding birds showing a positive agglutination reaction may lay eggs, from which are hatched chicks developing white diarrhœa symptoms, and at death the internal organs yield cultures which demonstrate morphologically an organism which is slender, non-motile, gram-negative, gelatine non-liquefying, and is aerogenic, demonstrating no acidity in maltose, dextrine and dulcite, the agglutination test would not be invalid as an economic measure in the identification of this infection. With this in mind, an experiment was carried out to this end.

Twenty breeding flocks were selected, all showing positively reacting birds, and the following spring all the dead chicks from these places were examined bacteriologically, with special reference to identifying the small gram-negative, maltose-dextrine-dulcite negative organism which was aerogenic. The following table shows the details of the tests: —

TABLE 7. — *Results on Identification of Cultures isolated from Dead Chicks which had been hatched from Eggs laid by Positively Reacting Breeding Birds.*

[Materials for study obtained from 20 different parts of Massachusetts.]

Flock Number.	Breeding Birds.		Cultures isolated from Dead Chicks.	(Fermentation) Acid in —			Gas Production (Aerogenicity) in Dextrose.	Agglutinability by Pullorum Serum.	Identification.
	Number in Flock.	Number with Positive Agglutination Test.		Maltose.	Dextrine.	Dulcite.			
1	51	16	2 Y 3 H 3 Y	— — —	— — —	— — —	+ + +	+C (1-400) +C (1-400) +C (1-400)	*Bact. pullorum* A
2	219	26	1 L 2 Y 3 Y 4 H	— — — —	— — — —	— — — —	+ + + +	+C (1-400) +C (1-400) +C (1-400) +C (1-400)	*Bact. pullorum* A
3	216	45	29 Y	—	—	—	+	+C (1-400)	*Bact. pullorum* A
4	51	20	22 L	—	—	—	+	+C (1-400)	*Bact. pullorum* A
5	36	3	24 Y 25 Y	— —	— —	— —	+ +	+C (1-400) +C (1-400)	*Bact. pullorum* A
6	1,194	244	29 Y	—	—	—	+	+C (1-400)	*Bact. pullorum* A
7	784	14	31 Y 32 Y 33 Y	— — —	— — —	— — —	+ + +	+C (1-200) +C (1-200) +C (1-200)	*Bact. pullorum* A
8	250	51	39 L 40 L	— —	— —	— —	+ +	+C (1-200) +C (1-200)	*Bact. pullorum* A
9	89	13	45 H	—	—	—	+	+C (1-200)	*Bact. pullorum* A
10	393	29	52 L 53 L 54 L	— — —	— — —	— — —	+ + +	+C (1-200) +C (1-200) +C (1-200)	*Bact. pullorum* A
11	138	21	60 L	—	—	—	+	+C (1-200)	*Bact. pullorum* A
12	76	6	61 Y	—	—	—	+	+C (1-200)	*Bact. pullorum* A
13	882	129	1 L 2 Y 3 Y 4 H	— — — —	— — — —	— — — —	+ + + +	+C (1-200) +C (1-200) +C (1-200) +C (1-200)	*Bact. pullorum* A
14	116	33	2 Y 3 H 3 Y	— — —	— — —	— — —	+ + +	+C (1-200) +C (1-200) +C (1-200)	*Bact. pullorum* A
15	264	71	1 Y	—	—	—	—	+C(1-200)	*Bact. pullorum* ?
16	110	46	2 Y	—	—	—	+	+C (1-200)	*Bact. pullorum* A
17	239	33	1 L	—	—	—	+	+C (1-200)	*Bact. pullorum* A
18	66	10	1 Y	—	—	—	+	+C (1-200)	*Bact. pullorum* A
19	38	11	2 Y 3 H 3 Y	— — —	— — —	— — —	+ + +	+C (1-200) +C (1-200) +C (1-200)	*Bact. pullorum* A
20	407	103	1 L 2 Y 3 Y 4 H	— — — —	— — — —	— — — —	+ + + +	+C (1-200) +C (1-200) +C (1-200) +C (1-200)	*Bact. pullorum* A

Y=unabsorbed yolk; H=heart blood; L=liver.

The results presented in this table need no comment. It can readily be seen that, with the exception of one culture obtained from flock No. 15, all cultures obtained from dead chicks which had been hatched from positive-reacting birds were maltose-dextrine-dulcite negative, and produced gas in dextrose. This is significant in that these flocks were widely distributed, and the only exception to this rule was the one noted above. This culture was maltose-dextrine-dulcite negative and was anaerogenic. At any rate, it gave none of the reactions for *Bact. sanguinarium.* On this experiment were 5,619 breeding hens and 924 were positive reactors, giving a positive agglutination up to dilutions of 1,000 and over. It is reasonable to believe that these results would be substantiated by a repetition of the experiment. While there are, as already noted, certain factors which have influenced the test and which may suggest need of modifications, — such as the validity of the agglutination tests, based on interagglutinability of *Bact. pullorum*, *Bact. sanguinarium* and other antigens in both *Bact. pullorum* and *Bact. sanguinarium* serum, — yet the fact remains that in the twenty flocks mentioned the agglutination test definitely located infection in 924 birds in a total number of 5,619. The differential characteristics of the cultures isolated from dead chicks which had been hatched from the eggs laid by these positive-reacting birds proved to be typical *Bact. pullorum*, conforming morphologically and biochemically to the standard set as a result of fermentative, serological and morphological studies completed.

After all is said about chances of error with the test, data are constantly being accumulated which indicate that the agglutination when carefully controlled through epidemiological work is at present the best method we have of locating *Bact. pullorum* infection and furnishing poultrymen a starting point for its elimination.

Summary.

From the foregoing data the following conclusions appear justified concerning the diagnosis of *Bact. pullorum* infection in the domestic fowl: —

1. From the fermentation studies conducted over a period of three years, it was found that *Bact. pullorum* is maltose-dextrine-dulcite negative and aerogenic, while all cultures of *Bact. sanguinarium* studied have been maltose-dextrine-dulcite positive and anaerogenic. These characteristics are constant. Whenever there has been question as to cultural and morphological differentiations, these investigations have shown that the biochemical tests have aided in making a final decision. Variations in morphology of the pullorum strains are frequent; therefore doubtful cultures should be submitted to the maltose-dextrine-dulcite test and checked by gas production in dextrose. Experience has shown that this procedure should be followed as a routine in all laboratories having to do with the pullorum problem.

2. From the examination of 600 avian specimens for the anaerogenic, non-motile, maltose-dextrine-dulcite positive form which produced en-

larged spleens associated with marked leukemic conditions, it was of some significance that the true sanguinarium culture was identified only six times. Chick examinations conducted during this same period, representing several hundred examinations, all yielded typical pullorum cultures. There was but one exception, and this culture was probably an atypical pullorum form which had become anaerogenic. In the examination of the adult avian specimens, the maltose-dextrine-dulcite negative forms isolated from several dead hens indicate that Hadley is correct in his contention that *Bact. pullorum* may assume a dual rôle: *Bact. pullorum* A being maltose-dextrine-dulcite negative and aerogenic, infecting young chicks; and *Bact. pullorum* B being maltose-dextrine-dulcite negative and anaerogenic, infecting adult hens. Cultures from eggs have always been aerogenic. If knowledge of *Bact. sanguinarium* is based upon the anaerogenicity of cultures, the absence of this property in cultures isolated from adult hens, chicks and eggs sent from all parts of the State would appear to indicate that fowl typhoid is not widely distributed in Massachusetts.

3. From pathological and bacteriological examination of 83 birds suffering with the so-called "paralysis," the evidence at hand does not indicate that the disease, so widely distributed at certain periods of the year, is due to the presence of the pullorum or sanguinarium type of organism.

4. The agglutination test has become a popular means of recognition in the domestic fowl of those individuals which have contracted infections in chickhood, and consequently, as adult productive fowls, may have become, through infections in their ovaries, carriers of infection to the offspring. During this investigation hundreds of agglutination tests have been made, demonstrating that there is an interagglutinability of *Bact. pullorum* with *Bact. sanguinarium*, *B. typhosus*, *B. paratyphosus* A and *B. paratyphosus* B antigens, with a consequent tendency to make the test lose in terms of specificity. The fact remains, however, as a result of experiments in this department, that in twenty flocks studied, representing 5,619 breeding birds, the test located infection in 924. Furthermore, the differential characteristics of the cultures isolated from dead chicks which had been hatched from eggs laid by these positively reacting birds proved them to be typical *Bact. pullorum*, conforming morphologically and biochemically to the standard set for this organism. Therefore, from these data, the conclusion seems justified that the agglutination test, when carefully controlled through epidemiological work, is at present the best method we have for locating *Bact. pullorum* infection and furnishing to poultrymen a starting point for its elimination.

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BULLETIN No. 210.

DEPARTMENT OF ENTOMOLOGY.

INJURY TO FOLIAGE BY ARSENICAL SPRAYS.

II. CALCIUM ARSENATES AND ARSENITES.
III. NOTES ON OTHER ARSENICALS.

BY H. T. FERNALD AND A. I. BOURNE.

In Bulletin No. 207 of this station the effects of lead arsenate sprays on foliage were discussed. In a similar way this bulletin gives the results of studies with calcium arsenates and arsenites, and the factors which appear to cause foliage injury following their use, together with notes on other arsenicals.

As in the case of the lead arsenates, the chemical work was done under the supervision of Dr. E. B. Holland of the Department of Plant and Animal Chemistry of the Experiment Station, and the applications of the materials and studies of the results were made by the Department of Entomology. All the statements made in Bulletin No. 207 with reference to responsibility for the various parts of the work, methods of application, and adequacy of methods, apply also to this part of the investigation.

II. CALCIUM ARSENATES AND ARSENITES.

Materials.

Pure Acid Calcium Arsenate. — To obtain pure calcium arsenate from manufacturers proved impossible, and a quantity of this substance was finally prepared by the Department of Plant and Animal Chemistry of this station. It was the acid arsenate ($CaHAsO_4 . H_2O$) and was a white powder consisting of rhombic crystals varying in size and with about 1 per cent of them broken. Analyzed, it gave the following: —

	Air Dry.	Dried.
Water	.120	–
Calcium oxide, CaO	28.300	28.334
Arsenic pentoxide, As_2O_5	57.955	58.025
Water of combination	13.630	13.646
	100.005	100.005

The powder, therefore, was a practically pure acid calcium arsenate. This substance proved very soluble on standing twenty-four hours, 44.82 per cent of the arsenic pentoxide entering into solution. The addition of milk of lime to the material was therefore tried, and after 1 per cent of this had been added, the amount dissolved was only .17 per cent. As finally used, the spray was accordingly prepared as follows: —

Four pounds of quicklime were slaked in about 40 gallons of water, just enough water being added at a time to maintain a brisk action without "drowning" the lime. After the slaking was completed, enough more water to make 50 gallons in all was added. Eighty-five hundredths of a pound of the arsenate was then mixed in, this being the amount calculated as necessary to give the spray the same strength of arsenic pentoxide as that of the lead arsenate sprays, in order to make the tests comparative. The material was strained into the spray pump and kept well agitated.

Commercial Calcium Arsenate. — This was a bulky, white powder consisting of minute spherical particles. It was purchased in the market, and on analysis proved not to be similar to the pure material considered above, but a combination of calcium and arsenic acid, with a considerable excess of lime. It might, perhaps, be fairly described as a basic lime arsenate. Its analysis gave —

	Per Cent.
Water, H_2O	1.38
Water in combination and occluded	2.92
Ferric and aluminum oxides	1.30
Calcium oxide, CaO	45.47
Magnesium oxide, MgO	.68
Sodium oxide, Na_2O	1.09
Arsenic pentoxide, As_2O_5	46.61
Sulfur trioxide, SO_3	.18
Chlorine, Cl	.02
Soluble silica, SiO_2	.16
Acid insoluble matter	.13
	99.94

This was not a pure material, but the impurities were not of such a nature nor present in such amounts as to be likely to cause injury to foliage.

Tests of the solubility of this material gave only a trace of arsenic pentoxide as dissolving after twenty-four hours' treatment with water. In order to make a direct comparison of this substance with the pure acid salt, milk of lime was added as described above, and 1.14 pounds of the arsenate were used for each 50 gallons of spray, this amount providing enough arsenic pentoxide to equal that used in the other tests.

Calcium Metarsenite. — Two samples of this material (both pastes) were tested, having been received from manufacturing companies. Their analyses follow: —

I.	Per Cent.
Water, H_2O	67.87
Calcium oxide, CaO	6.78
Arsenic trioxide, As_2O_3	23.87
Arsenic pentoxide, As_2O_5	.09
Magnesium oxide, MgO	.05
Sodium oxide, Na_2O (estimated)	.70
Chlorine, Cl	.80
Insoluble matter	.01
	100.17

The original composition of this material was probably about as follows: —

	Per Cent.
Water, H_2O	67.87
Calcium ortho arsenate, $Ca_3\ (AsO_4)_2$	.18
Calcium metarsenite, $Ca(AsO_2)_2$	30.31
Magnesium metarsenite, $Mg(AsO_2)_2$	.30
Sodium chloride, $NaCl$	1.32
Insoluble matter	.01
	99.99

This substance gave 11.58 per cent of soluble arsenic trioxide on standing in water for twenty-four hours, showing at once its dangerous nature when applied to foliage. When mixed with milk of lime, however, the amount soluble was greatly reduced, but even then safety could not be obtained with any certainty.

II.	Per Cent.
Water, H_2O	79.03
Arsenic trioxide, As_2O_3	16.20
Arsenic pentoxide, As_2O_5	.03
Calcium oxide, CaO	4.51
Magnesium oxide, MgO	.05
Sodium oxide, Na_2O (estimated)	.07
Chlorine, Cl	.03
Organic matter, etc.	.08
Insoluble matter	.01
	100.01

The original composition of this material was probably substantially as follows: —

	Per Cent.
Water, H_2O	79.03
Calcium ortho arsenate, $Ca_3(AsO_4)_2$	.06
Calcium metarsenite, $Ca(AsO_2)_2$	20.34
Magnesium metarsenite, $Mg\ (AsO_2)_2$	.30
Sodium arsenite, $NaAsO_2$	.13
Sodium chloride, NaCl	.05
Organic matter, etc.	.08
Insoluble matter	.01
	100.00

The arsenic in this material, also, proved so soluble on standing in water as to make it unsafe for application to foliage. It was tested both in water alone and with the addition of various percentages of milk of lime. With both samples, enough was taken to give the standard amount of arsenic, so that the treatments should be comparable with those made with the lead arsenates and lime arsenates.

Experimental Work.

The materials described above were sprayed upon the apple, cherry, peach, pear, plum and elm, under the same conditions as given in Bulletin No. 207, and the results obtained follow.

Pure Acid Calcium Arsenate with 1 Per Cent Milk of Lime. — The apple, sprayed with this material in clear weather, shows injury above the safety line (Fig. 1, AB), from high temperature with low humidity to low temperature with high humidity. The line for the greater part of its course runs lower than the safety line for lead arsenates, though at the high humidity end the reverse is true to a slight degree. As the general safety line for the apple is much below most of those given in clear weather, the difference is more marked by comparing any of the clear weather lead arsenate safety lines in Bulletin No. 207 with Fig. 1, than when the general one is used. The evidence is that pure acid calcium arsenate with 1 per cent milk of lime cannot be used on the apple at as high temperatures and humidities as the lead arsenates in clear weather. This is true, also, for cloudy weather, though the difference is not so great.

On the pear, clear-weather tests gave six cases of injury above the safety line (Fig. 2, AB), which runs considerably higher than in the case of the apple. In the cloudy weather tests (Fig. 2, CD), as was the case with the lead arsenates, the pear is evidently much more resistant to spray injury than the apple.

In the case of the cherry (Fig. 3), the leaves are more liable to injury than the apple, but less so than the plum. The cloudy weather safety lines for the cherry and plum (Figs. 3 and 4, CD) are very nearly the same, however. With the plum, temperature seems to play an important part, injury beginning in clear weather at quite a low point, while high humidity seems to be less dangerous (Fig. 4, AB).

Safety Lines for Spraying with Pure Acid Calcium Arsenate.

AB, clear weather; CD, cloudy weather.

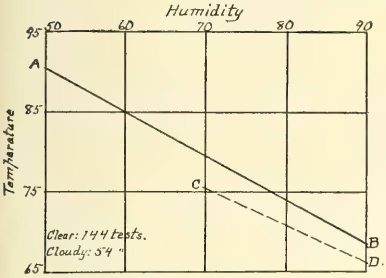

Fig. 1. — Apple.

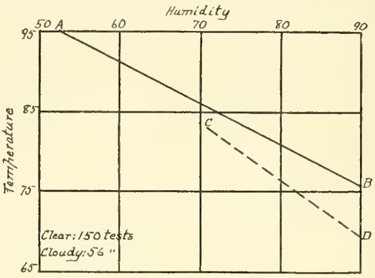

Fig. 2. — Pear.

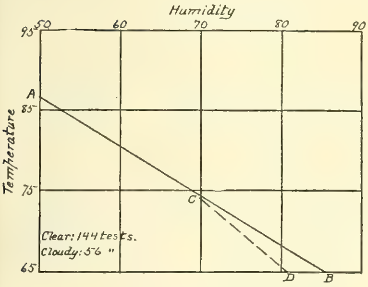

Fig. 3. — Cherry.

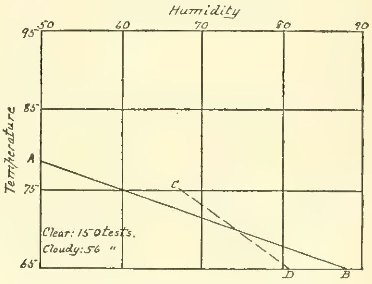

Fig. 4. — Plum.

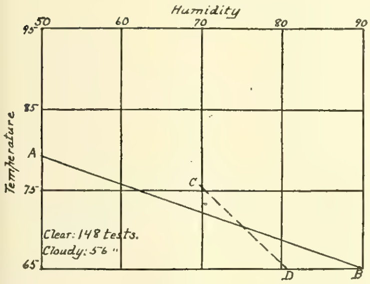

Fig. 5. — Peach.

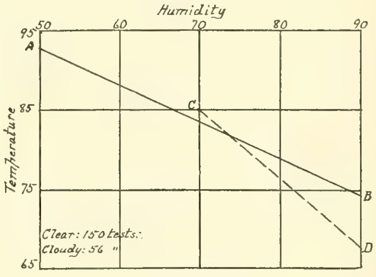

Fig. 6. — Elm.

The peach (Fig. 5) quite closely follows the plum in its resistance to calcium arsenate, and the two figures (4 and 5) show no more difference than might perhaps easily disappear could a greater number of tests have been made.

The elm (Fig. 6) is evidently less resistant to pure acid calcium arsenate than the pear, as eleven cases of injury were obtained above the safety line AB of the figure, in clear-weather tests, and the line itself runs considerably lower than that for the pear. In cloudy weather the elm also appears to be more easily injured at high humidities, even if the temperature is low.

Commercial Calcium Arsenate with 1 Per Cent Milk of Lime. — On the apple (Fig. 7) this material gives results differing little from those obtained with the pure acid calcium arsenate described above. The cloudy weather tests suggest a little greater safety with the commercial material at medium combinations of temperature and humidity, but the rather small number of tests obtained makes this difference less significant than if similar results had been shown by a larger number.

In the case of the pear (Fig. 8) no injury was obtained following any of the tests, and AB is simply placed along the highest tests obtained. Whether higher combinations of temperature and humidity would have shown injury could they have been obtained, is, of course, unknown. The cloudy weather safety line CD is more satisfactorily located, three cases of injury having shown that the line could not be placed higher.

Tests of the cherry (Fig. 9) give in general an agreement between the two materials (compare Figs. 3 and 9), though the commercial substances seem, as in the case of the apple, to be a little safer at medium combinations of temperature and humidity.

With the plum (Fig. 10) it would seem that the commercial material can be used with safety at a considerably higher temperature than the pure when the humidity is low (86° as compared with 79° at 50° humidity). Aside from this, nothing of significance appears on comparing Figs. 4 and 10.

On the peach (Fig. 11) the two materials give almost identical results (compare Figs. 5 and 11). On the elm (Fig. 12) the commercial article appears to be safer in clear weather than the pure substance (compare Figs. 6 and 12), although one doubtful injury at 85° humidity suggests that the point B on Fig. 12 may be too high.

Comparison of the safety lines obtained on the different kinds of foliage tested with commercial calcium arsenate in clear weather brings out several points of interest. The elm (Fig. 13, 2) would at first seem to be more resistant than the pear (1), particularly at high T and low H. It should be remembered, however, that line 1 was located along the highest tests obtained, no injury showing up to that line, and no tests being available above it. It is not improbable that this line could go considerably higher than where it is now located. The cherry (4) is more resistant than the plum (5) at high T, but slightly the reverse holds at high H, and both,

SAFETY LINES FOR SPRAYING WITH COMMERCIAL CALCIUM ARSENATE.

AB, clear weather; CD, cloudy weather.

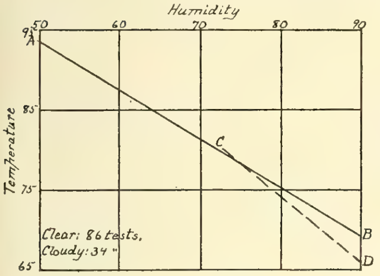

FIG. 7. — Apple.

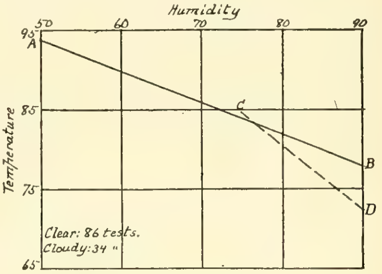

FIG. 8. — Pear.

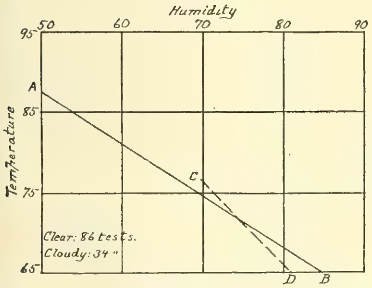

FIG. 9. — Cherry.

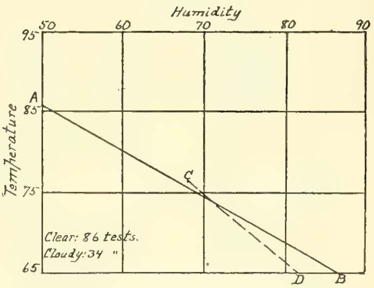

FIG. 10. — Plum.

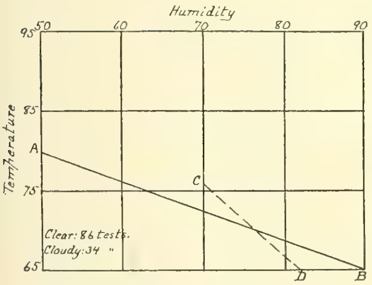

FIG. 11. — Peach.

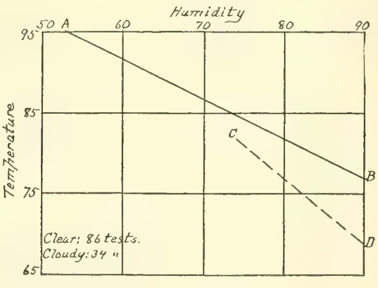

FIG. 12. — Elm.

at this end of the figure, are less resistant than the peach (6), though at high T the latter is considerably less resistant than the other two.

In cloudy weather (Fig. 14) the pear, elm and apple show about the relative relations to each other that would be expected from the studies on lead arsenates, while the cherry, plum and peach are almost identical for the high H limit of safety, and nearly so at the other ends of their safety lines. Such differences as they do show might easily disappear were more tests available, though, on the other hand, such tests might have led to greater differences.

Finally, it is evident that there is a wide difference in the safety lines, and that the spraying of different kinds of trees cannot always be done with safety on the same day. It may be perfectly safe to spray apples on a day when spraying plums, peaches or even cherries might prove disastrous.

Calcium Metarsenite. — The two samples of this substance described above, produced injury on the foliage of all the kinds of trees tested, within two or three days after the application, the injury increasing until the leaves were practically destroyed and dropped off. Though the addition of milk of lime appeared to bring down the solubility of the arsenic within reasonable safety limits in laboratory tests, this did not appear to hold under field conditions, even when the milk of lime was increased to 3 per cent, so further investigation of this material was given up.

III. NOTES ON OTHER ARSENICALS.

Magnesium Arsenate. — This substance, sent in by an insecticide manufacturing company for trial, was tested on the same basis as the other materials. Two hundred and eight clear-weather tests were made at temperatures and humidities ranging from T92 H54 through T86 H70 and T80 H80 to T77 H81, for the high limits, and as low as T78 H55 and T67.5 H 69. In every case, no matter how low T and H were, injury developed on all the trees except the pear and one or two tests on the elm. Apparently, spraying with magnesium arsenate is unsafe at almost any combinations of T and H, except on the pear, where the higher combinations become unsafe, and possibly on the elm, where at low combinations only traces of injury were evident.

In cloudy weather 108 tests were made at combinations of T and H as low as T73 H76 and T67 H72, and as high as T82 H74, T78 H84 and T68 H90. In every test injury, often very serious, followed, except in two instances on the pear.

As a general conclusion from these tests, therefore, magnesium arsenate is not a safe material for spraying under any conditions.

Zinc Arsenite. — Two samples of this material, received from different manufacturers, were tested in 1913. Both were finely divided, bulky powders, light and "fluffy." They were applied, at the rates of 1 pound and $1\frac{1}{2}$ pounds in 50 gallons of water, to the same kinds of trees as were

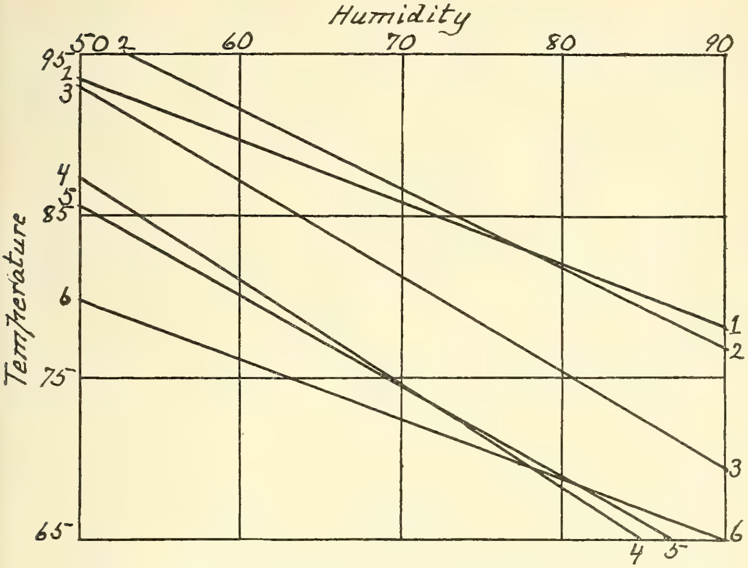

FIG. 13. — Safety lines for spraying with commercial calcium arsenate in clear weather: 1, pear; 2, elm; 3, apple; 4, cherry; 5, plum; 6, peach.

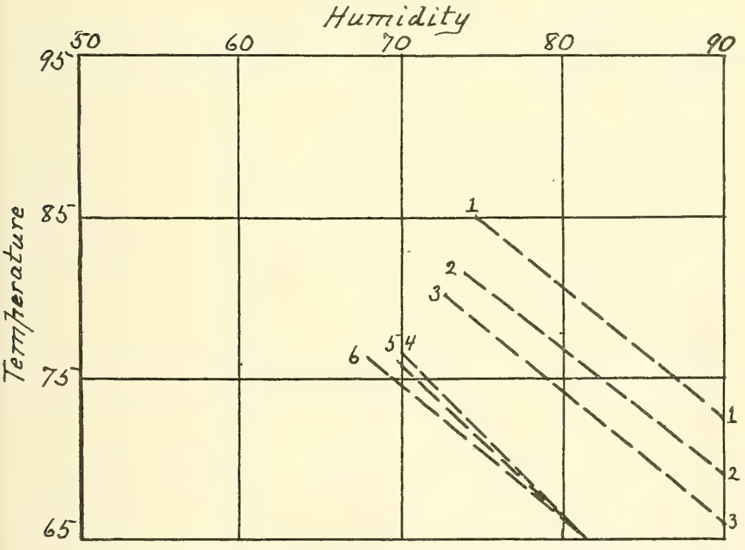

FIG. 14. — Safety lines for spraying with commercial calcium arsenate in cloudy weather: 1, pear; 2, elm; 3, apple; 4, cherry; 5, peach; 6, plum.

used for the other tests, and in every case injury followed, generally severe. Clear or cloudy weather seemed to give little difference in the results, and spraying at low T and H combinations produced injury as certainly as with high combinations of these factors. Extensive tests of zinc arsenite, therefore, were not continued.

SUMMARY.

1. Pure acid calcium arsenate is not on the market. Tests with it indicate in a general way that the same factors determining injury to foliage hold good as with the lead arsenates, but that the safety lines run lower.

2. With commercial calcium arsenate the safety lines run about as high (in some cases a little higher) as with the pure material, but lower than with the lead arsenates. In the case of the peach, however, the safety line does not differ greatly from that obtained with the lead arsenate powder.

3. It is possible that the excess of lime in the commercial calcium arsenate may be sufficient to prevent the arsenic pentoxide from entering into solution. Further tests are needed on this point, as considerable time and bother can be saved if the addition of milk of lime is unnecessary.

4. In general, lime arsenate does not give as satisfactory results as the lead arsenates, the range of T and H combinations at which it is safe being more limited.

5. The spraying of different kinds of trees with commercial calcium arsenate cannot always be done with safety on the same day. The treatment may be safe on some kinds of trees under conditions which make it dangerous to others.

6. Calcium metarsenite is not safe for use on fruit tree foliage.

7. The same is true for magnesium arsenate and zinc arsenite — at least for the samples tested.

BULLETIN No. 211.

DEPARTMENT OF POULTRY HUSBANDRY.

CHANGES IN EGG PRODUCTION IN THE STATION FLOCK.

BY H. D. GOODALE AND RUBY SANBORN.

Introduction.

For the past eight years the work of the Massachusetts Agricultural Experiment Station with poultry has centered about the problem of breeding better layers. A certain measure of success has been reached. The present paper is a descriptive history of the work. The theory that is under test, the plan of procedure, the results secured to date, with such comment as seems to be required to prevent misinterpretation of the data, with such suggestions as can be offered to the breeder, are presented.

The Working Hypothesis.

The studies were begun in December, 1912. It was then supposed that the inheritance of fecundity was a simple two-factor Mendelian matter, but it was not long before it gradually became clear that, with Rhode Island Reds, the egg record made by a bird was the result of the combined action of a number of inheritable characteristics.

Simplifying matters as much as possible, five main characteristics may be recognized, namely: —

1. Maturity.
2. Rate (intensity).
3. Broodiness.
4. Point at which production ceases (persistency).
5. Winter pause.

Each component is very variable. Resulting egg records from combinations of these five variable characteristics are illustrated in Figs. 1 and 2. In Fig. 1 are used the two extremes only of each of the five components, which make 32 possible combinations, each illustrated by an actual

Fig. 1. — Typical Egg Records.

Illustrative of the part played by several factors in determining the number of eggs laid.

BAND NUMBER	FORMULA	DATE HATCHED	AGE AT FIRST EGG	NUMBER EGGS PER MONTH															365 DAYS	TOTAL
				SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.		
B 357	ENFCA	MAR 25	187	3	25	25	19	22	18	24	21	27	28	22	28	26	17		286	305
B 8324	ENFCQ	APR 4	192		10	19	23	19	18	24	21	23	23	25	23	10			238	238
B 8566	ENFPA	APR. 11	185		12	23	18	20	1	25	25	27	22	26	23	23	12		254	257
B 8355	ENFPQ	APR 4	177	3	20	22	26	4	16	18	21	26	25	22	25	6			232	232
B 8336	ENSCA	APR. 4	185		11	21	18	16	14	18	16	16	16	19	20	18	8		206	211
B 3033	ENSCQ	MAR. 31	193		15	10	14	15	16	19	17	20	12	9					147	147
B24	ENSPA	MAR. 18	191	4	22	9	1	13	13	18	20	17	15	18	17	17	10		181	194
B 4440	ENSPQ	MAY 5	187			10	16	12	10	13	13	17	9		15	4			119	119
8490	EBFCA	APR. 30	170		13	26	29	25	20	21B	17	B12	B14	B14	B1	12	8		210	212
B 3245	EBFCQ	APR. 7	182		23	14B	25	B6	19B	18	B16B	14B	12B	13	10B				170	170
B 8008	EBFPA	MAR. 28	194		8	25	22	5	15	25	B15B	15B	15B	B7	B13	B9	B6	7	190	197
B 2885	EBFPQ	MAR. 31	182	1	27	18		17	21	22	25	25	B9	20B					185	185
8751	EBSCA	MAY 7	193			11	10B	17	B11	12B	16B	12B	12B	11	9	B10	4		135	135
B 2185	EBSCQ	MAY 3	197			2	18	16	16	20	17	9B	10B	8	B3	13B			132	132
B 2907	EBSPA	MAR. 31	190		4		12	18	15	8	14	17B	21	19	B7	11	11		150	150
B 4512	EBSPQ	MAY 5	189			8	19		15	B11	B9	B1	B3	5B					81	81

B8080	LNFCA	MAR. 28	217		1	20	22	19	19	22	22	25	25	24	26	20	17		262	262
B9028	LNFCQ	APR. 25	221				23	22	15	22	22	26	24	23	14				191	191
B8105	LNFPA	MAR. 28	221			20	23	4	21	24	27	28	22	24	22	19	14		248	248
B9027	LNFPQ	APR. 25	217			2	6	25	21	26	27	29	22	24	14				196	198
B587	LNSCA	APR 1	248				17	17	15	15	17	17	1	16	1	18	10		144	144
8087	LNSCQ	APR. 9	217			8	19	15	13	14	10	12		6	2				99	99
B63	LNSPA	MAR. 18	203		14	19	5		7	10	16	19	15	19	20	16	2		162	162
B3089	LNSPQ	APR 7	292					1.	5	10	18	10	3						47	47
119	LBFCA	MAR 23	246			5	26	24	25	27	19^B	15^B	14	^B13	^B14	^B14^B	12		208	208
B4082	LBFCQ	APR. 28	240				5	24	24	24	^B20	^B16	^B14	^B13	^B10	^B8			158	158
7918	LBFPA	APR. 2	226			1	14	25	2	22	28	^B15^B	6^B	10^B	9	5	11		148	148
B2818	LBFPQ	MAR 31	234			8	17		11	28	25	25	24	13	20^B				171	171
803	LBSCA	APR. 27	228				14	15	14	15	11^B	9^B	7	^B4		6	10		105	105
8602	LBSCQ	APR. 30	227				13	17	17	13	15^B	16^B	13	^B	19				123	123
7697	LBSPA	MAR. 19	268				6	19	3	12	16^B	^B6	^B9	9^B	17	4	8		119	119
8941	LBSPQ	MAY 14	254					4	3	19	12^B	6^B	7^B						51	51
B1209	LNS-Q	APR 22	274					1.	1.		1		2		2	2			9	9
B1202		APR 22																	0	0

Legend: E, early (laid before 201 days of age); B, broody; F, fast (usually laid at the rate of more than 21 eggs per month); P, winter pause of ten or more days; A, persistent (continued production later than September 30); L, late (laid after 200 days of age); N, not broody; S, slow (usually laid less than 22 eggs per month); C, continuous (no winter pause); Q, quitter (stopped laying before October 1). Classification of broody birds in respect to rate is based on the non-broody months. For certain combinations it has not been possible to find records that fit the definitions closely in all respects. The horizontal lines indicate periods over which production extended; a pause of ten or more days is shown by a break in the line; B above the break indicates a broody pause. Under the heading Total is given the production for the biological laying year, which sometimes exceeds the 365-day year.

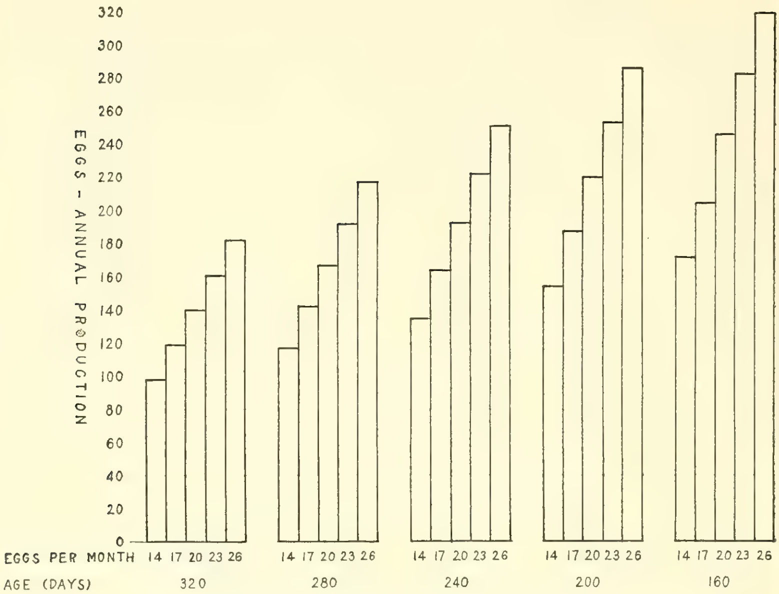

Fig. 2. — The Effect of Variation in Two Factors.

Five points of maturity and rate are chosen, and it is assumed that each bird was hatched April 15, was non-broody, was without winter pause and stopped laying September 30.

record. Fig. 2 was made by choosing five points of the first and second characteristics (maturity and rate), assuming that the other three remain unchanged, and showing by artificial records what would be the resulting yearly production. If all the variations of all the characteristics were combined in all possible ways, the number of different egg records secured would be in the thousands.[1] Environment is also responsible for much variation in production.

If the records of the highest producing hens are examined, it is to be noted that they begin early in life (and also fairly early in the season) and continue at a steady and relatively high rate throughout the twelve months. Examined from the negative standpoint, it is noticed that there are no broody pauses, no winter pause, no delay in beginning production, no early cessation of production, no slow rate while laying. A record at the low end of the series is zero, but one only shortly removed shows late maturity, early cessation and slow rate. The problem of the breeder, then, is to devise a method of eliminating the undesirable characteristics from the flock and of securing fairly uniform high production.

[1] It is a point of considerable importance to recognize that the greatest complexity occurs in those records near the mode of the egg production curve, and that those records near each extreme are less complex, so that studies made on a flock composed of either very high or very low producing birds will be simpler than if made on flocks of average production.

As long as attention is fixed solely on the number of eggs laid, and no recognition given to the fact that the difference between a 150-egg hen and a 200-egg hen is something more than just 50 eggs, progress in getting at the fundamentals of the inheritance of egg production is hindered. The solution of the problem demands that the inheritance of each component be ascertained by specially planned experiments. This would require about fifty years of one man's time, with a flock of 500 pullets trapnested through their first laying year.

The policy which was therefore adopted at this station was, using as a working theory the concept of an egg record as briefly outlined above, to establish a high-producing strain by improving the flock step by step, making it fairly homogeneous for one of the five characteristics and then for another. In this way there would eventually be built up a flock which would meet the standards required for the highest production. At the same time it was planned to make an intensive study of broodiness and to collect data on the other characteristics, with the purpose of gaining as much useful information as possible.

Plan of Procedure.

The Foundation Stocks.

The foundation stock as a whole proved deficient in desirable characteristics. The birds were late maturing and, when hatched in April or May, did not begin laying till midwinter. Many stopped producing by midsummer or soon after. The winter pause was present but not conspicuous because of the late start made. Rate of production while laying was excellent. The birds were deficient in vitality and were poor breeders. It was essential, of course, to remedy these last two defects before further work could be done. Stock of good vitality was added, but unfortunately the general satisfactory rate of production was lost and the winter pause accentuated, so that, as the next paragraph shows, ground was lost for the time being. (See Fig. 5, p. 109.)

The members of the flock hatched in 1915 were, on the whole, late maturing and broody, and exhibited a well-marked winter pause in early layers, a slow rate, and a tendency to stop production early in the summer. There were, however, individuals which matured early, others that were not broody, some that laid at a high rate, some that persisted in production till late fall, and some that lacked a winter pause. Individuals exhibiting various combinations of these characteristics also occurred, but there were none in which all the desired characteristics were combined. This was to be accomplished by breeding, and the present plan of procedure, vaguely formulated the year before, was put into active practice.

Basis of Selection of Breeding Females.

Beginning in 1916, female breeders were selected primarily for early maturity, and late maturing individuals used only when exceptional in other respects. A fair approach to the objective was obtained in the

laying flock of 1917–18, partly through a fortunate nick between a single pair.

Meanwhile, the intensive work on broodiness had given a flock comparatively free from broodiness, so that it was known that broodiness could be very much reduced even if not eliminated. The next step was an attempt to fuse the low-broody strain, which were poor producers, with the early maturing line, which were good layers, by choosing non-broodies from the latter and good layers from the former. Of course, it was expected that the fusion would result in a temporary setback. The first year after the fusion, 1919–20, fewer eggs were laid and more broody birds occurred in the combined flocks than in the respective contributing strains, but this difficulty has been overcome. On reviewing the situation, it is clear that the desired objective would have been reached had the non-broody members of the high line alone been used, for these birds are the ones that constitute the major portion of the ancestry of to-day's flock.

While concentrating on maturity and broodiness, some progress has been made in eliminating the winter pause, and in securing larger numbers of birds that lay at a high rate. Data covering these statements are given in later sections of the paper. The proportion of birds in the flock that approach the desired type is much greater. With the increase in the number of birds approaching the desired type, birds with records that would have qualified them for breeders in the early stages of the work are now rejected. The basis of selection has been progressively altered and selection made progressively more stringent, as shown in Fig. 3 and Table I.

TABLE I. — *Data on the Mothers of the Several Flocks.*

Mothers of Pullets Hatched in —	Mean Age at First Egg.		Mean Winter Production.		Mean Annual Production.	
	Number of Birds.	Days.	Number of Birds.	Eggs.	Number of Birds.	Eggs.
1913	–	–	72	26.72	42	123.52
1914	36	252.89	59	40.17	49	141.02
1915	89	253.45	118	29.07	92	122.62
1916	60	228.60	61	47.38	57	147.72
1917	40	198.93	39	76.18	36	186.36
1918	25	193.08	25	92.76	22	204.41
1919	29	199.79	29	85.69	28	222.68
1920	38	197.71	37	84.78	16	228.06

In each case those mothers only are included having daughters with a corresponding record. Because of the clean-up in June, 1920, an exception is made so that the annual production for 1919 is for birds having daughters that laid up to June 1. For the first four years birds of the original stock whose hatching date is unknown were used in decreasing numbers as breeders, which accounts for the small number of birds whose mean age at first egg is given.

Other qualifications besides those exhibited in the egg records are required. A hen is a good breeder only if she produces such a number of pullets that they constitute a satisfactory index of her capacity (with a given mate) to transmit her own good laying qualities. Small families are undesirable, because they are often an inadequate sample of a bird's real breeding quality. As soon as it appears that a breeder's eggs are not hatching well, she is taken from the breeding pen and her offspring discarded. A few breeders are discarded for other defects, such as low vitality of their progeny.

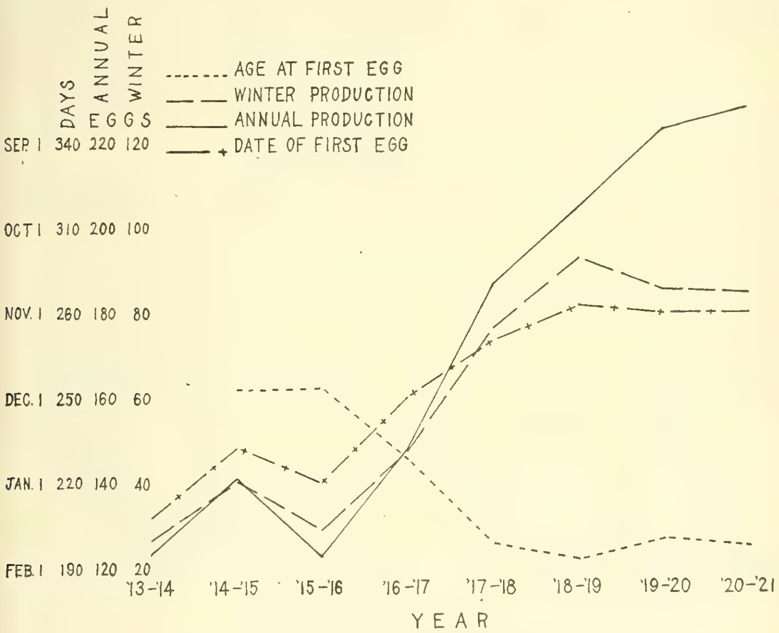

Fig. 3. — Mean Production of Female Breeders.
(From data given in Table I.)

Basis of Selection of Breeding Males.

The selection of suitable males is quite simple. First, each one comes from a large family and is the strongest, the most vigorous and usually the largest member of the group; second, he comes from a good mother; and third, the most important point of all, his sisters must have made good records.[1] The family which produces the largest proportion of females capable of qualifying as breeders is the first choice for one or more males. Naturally, males will be chosen from several families and always such as stand highest in desired characteristics.

[1] This involves keeping one or more representatives of each family till his sisters' records are available.

Continued Use of Breeders on the Basis of the Performance of their Offspring.

Birds used as breeders are kept till the records of their progeny are at hand. Many fail to transmit the desired qualities, either wholly or to a sufficient number of their progeny, and therefore are discarded. Exceptions are sometimes made with females that are otherwise remarkable, in the hope that they may nick better with another mate. Those birds that show pronounced ability in producing offspring that make egg records of the desired type may be bred several years in succession. The importance of a very few birds of this sort cannot be too greatly emphasized, for through these progress is made.

Points in Management that affect the Results.

A few points in the handling of the flocks need especial emphasis, as they bear directly on the interpretation of the results.

Flock Number. — Throughout these experiments the pullets have been kept in relatively large flocks, 100 to 125, while making their records, with the following exceptions: in 1912–13 there were two pens of 72 birds each; in 1913–14 there was one pen of 72 birds and several smaller groups of 25 to 35 each; in 1914–15 the pedigreed pullets were in large flocks, but the new stock was in smaller groups. The latter are excluded from the averages. Some years the high-line birds, or part of them, have been penned by themselves; other years they have been scattered through the flock. They have received exactly the same treatment that was given the rest.

The selection of the pullets that are put into the laying pens is based on the family. The best families having been decided upon, all the daughters in those families are included except those of exceedingly poor vitality, amounting to less than 5 per cent. As far as possible, families (offspring of one mother) containing fewer than seven daughters each are excluded. This has been done in order to enable a fair judgment of the breeding ability of any mother to be made. An exception was made to this rule in 1920–21, when all daughters weighing less than 3 pounds 6 ounces at four months of age were excluded. The effect of such exclusion, if any, on egg production is slight, as shown by correlation tables.

The time of year in which a flock of birds is hatched is one of the most important factors in determining the number of eggs laid. This is illustrated in several figures and tables, of which Fig. 13 (page 117) may be especially cited. Note that the late hatched flock loses about two months' production, — a production that, as far as the records show, is not compensated for, except in slight measure, at other seasons.

It is the practice at this station to hatch weekly. The length of the hatching season has varied from year to year, but, unless otherwise stated, only records made by birds hatched between March 25 and May 14, inclusive, are presented in this paper. The mean hatching date is April 18, from which the several yearly means vary little as shown by Table II.

TABLE II. — *Data on the Flocks of 1912–20.*

PULLET YEAR.	HATCHING DATE.[1]		DATE OF FIRST EGG.		AGE AT FIRST EGG.			WINTER PRODUCTION.			ANNUAL PRODUCTION.		
	Mean.	Change from 1913 (Days).	Mean.	Change from 1912 (Days).	Number of Birds.	Mean Number of Days.	Change from 1913 (Days).	Number of Birds.	Mean Number of Eggs.	Change from 1912 (Eggs).	Number of Birds.	Mean Number of Eggs.	Change from 1912 (Eggs).
1912–13	–[2]	–	Jan. 19	0	–	–[2]	–	138	28.39[3]	0.00	123	114.38[3]	0.00
1913–14	Apr. 19	0	Dec. 31	–19	168[4]	255.61	0.00	171	36.44	+8.05	171	123.64[5]	+9.26
1914–15	Apr. 19	0	Jan. 26	+7	115	282.80	+27.00	113	13.27	–15.12	80	103.25	–11.13
1915–16	Apr. 18	–1	Jan. 7	–12	224	264.27	+8.66	237	29.44	+1.05	208	121.70	+7.32
1916–17	Apr. 19	0	Dec. 5	–45	329	229.71	–25.90	328	42.46	+14.07	294	133.67	+19.29
1917–18	Apr. 17	–2	Nov. 16	–64	291	212.96	–42.65	280	59.40	+31.01	237	165.85	+51.47
1918–19	Apr. 19	0	Oct. 30	–81	141	194.44	–61.17	109	63.45	+35.06	64	169.19	+54.81
1919–20	Apr. 20	+1	Nov. 18	–62	157	212.04	–43.57	124	58.23	+29.84	–[6]	–[6]	–[6]
1920–21	Apr. 12	–7	Oct. 29	–82	168	199.99	–55.62	160	67.65	+39.26	109	199.73	+85.35

[1] Mean hatching date based on birds that completed the winter.

[2] Mean hatching date and mean age at first egg not known for 1912.

[3] Five eggs arbitrarily added as November's quota, since trapnesting was not begun until December.

[4] Is less than 171 because of birds that never laid; kept through winter but not through year.

[5] Because of limited facilities, only 59 birds in 1913–14, hatched between the limiting dates, were trapped throughout the year. They were a selected group with an average winter production of 41.92 eggs against 36.44 for the entire flock, which, therefore, has a probable mean annual production of 123.64 eggs.

[6] Records stopped June 1. See p. 108.

Successive years do not represent successive generations. The later years include the offspring of selected parents belonging to several generations.

Floor eggs are excluded from all the data used in this paper. Artificial lighting has not been used.

Because of the prevalence of disease, the whole plant, both college and experimental, was given a thorough cleaning during the summer of 1920. All adult birds were disposed of June 1, so there are no annual records for that year.

Seasons at which Increased Production is most Desirable.

The average well-cared-for flock of pullets of American breeds begins production some time in late fall or early winter, reaches its maximum

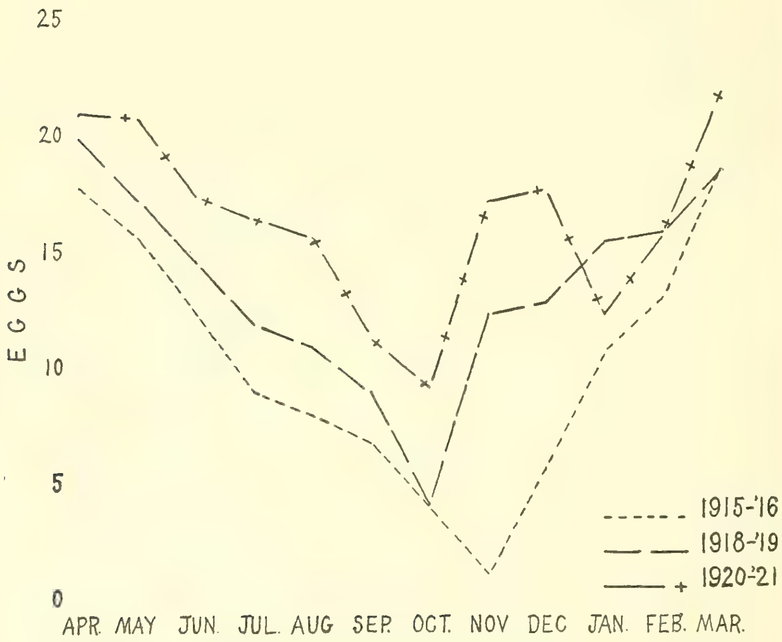

Fig. 4. — Seasonal Distribution of Production.

The right-hand part of the curve beginning with November precedes, chronologically, the left-hand portion. This arrangement emphasizes lack of production in certain months.

in March or April, and then declines more or less rapidly toward zero the following autumn, as represented in Fig. 4. The curve starts at the high point in April and ends at the high point in the preceding March, instead of starting with the beginning of production, as is customary. This arrangement emphasizes the hollow between the two high points. It is clear that if good production can be obtained in October, November and

December it should not be hard to improve production in other months, where necessary. Hence, emphasis is laid on winter production, so called, as at this season eggs bring two to two and one-half times the price paid in April. The producer who can secure a 50 per cent yield in those months will reap the reward due to his ability, at least in the immediate future, while if the methods by which such a yield is obtained become common practice, the consumer will benefit through lower prices and steady supply. While the producer may not continue to reap the harvest due to pioneer methods, his business will be on a firm basis, with the period of all outgo and no income eliminated.

The desirability of increased fall and winter production is made clearer by a comparison of the station flocks with certain farm contest flocks in Missouri as reported by Townsley (1920). The latter's average November production for the last four years ranges from 2.0 to 2.5 per hen, being 2.3 eggs each for nearly 25,000 birds in 1920. The best flock of 124 birds averaged 8.1 eggs each. On the other hand, a flock of high-line birds of similar size at this station averaged 18 eggs each. If all the flocks of the country were as good layers as this particular flock, — and there is no biological reason why they should not be, — it is apparent that both consumer and producer would benefit.

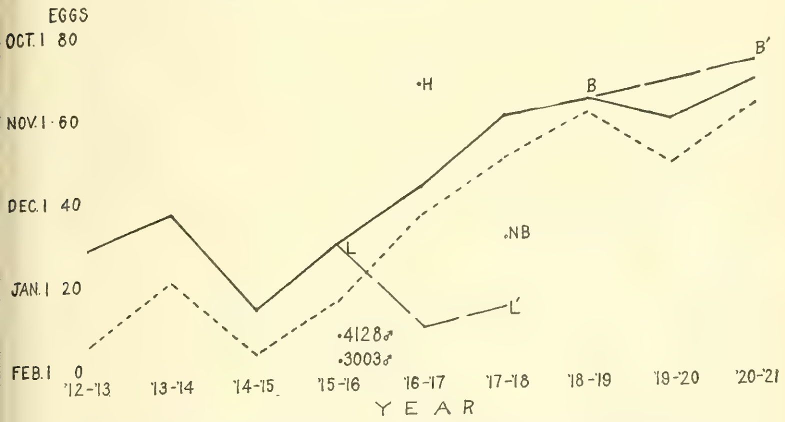

Fig. 5. — Winter Production and Date of First Egg for Flocks of 1912–20.

Solid line represents mean winter production. Up to but not including 1917–18, the mean for the entire flock is given. From 1917–18 on, it is for the high line only. L–L′, low line. B–B′, original high line. H, mean of several high families in 1916–17. NB, mean of low-broody flock. 4128♂ and 3003♂, mean of daughters of the respective males.

Dotted line represents mean date of first egg for set of birds making winter records shown in continuous line.

Results secured.

Data on mean winter production, mean annual production, and mean age at first egg are presented for each year of the experiment. Data on broodiness have been recently published and need not be repeated here.

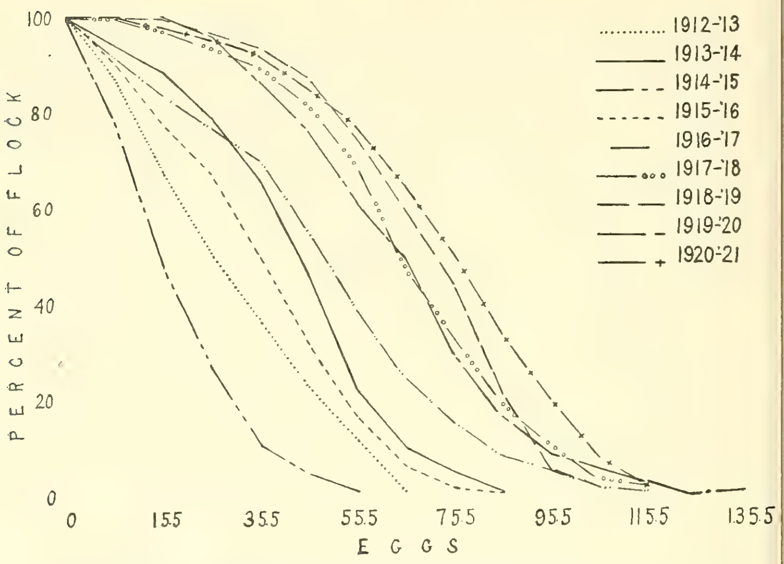

FIG. 6.—Integral Curves showing the Percentage of Each Flock having a Winter Egg Production as Great as that indicated, or Greater.

No allowance made for November in 1912. (See Table II.)

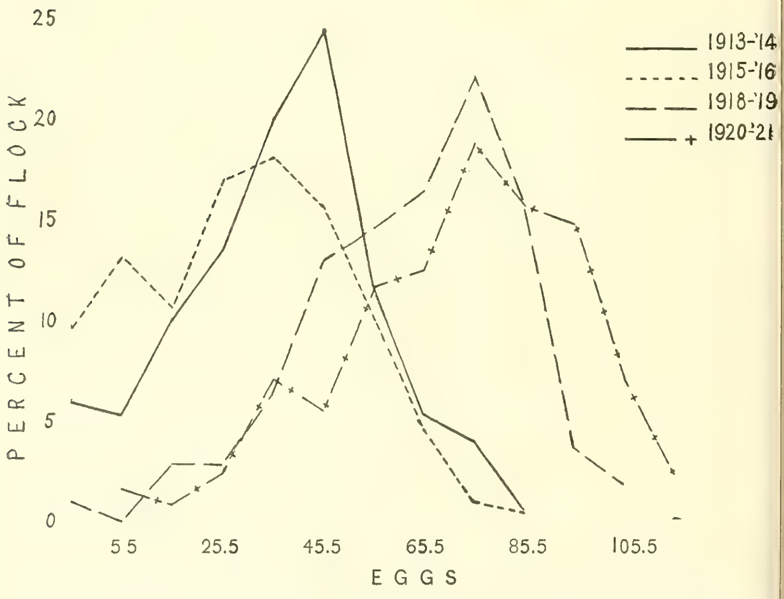

FIG. 7.—Frequency Polygons showing the Percentages of Flocks having Winter Production indicated.

1920–21 curve is for the original high line only.

Data on the initial cycle, winter pause, spring production, summer production, date of last egg and rate of production are restricted to certain years, because breeding for changes in these characteristics has necessarily been secondary. They indicate clearly such changes as have occurred. For purposes of clarity, intermediate years are omitted in certain graphs.

Changes in Mean Winter Egg Production.

Winter egg production is defined as the number of eggs laid prior to March 1 in the first laying (pullet) year. In Table II, represented graphically in Fig. 5, is given the mean winter production of the flocks from 1912 to 1920, inclusive. A high-line strain, as a definite entity, was not propagated until 1917. From 1917 on, the winter production given in the table and graph is that of the high line. A low line, L–L[1], Fig. 5, was propagated in a small way for a time, but finally lost. In 1917 a point is indicated for comparison with the high line which is the weighted production of a flock bred primarily for absence of broodiness, and in whose establishment all non-broodies available, high producers or low, were mated with three males: No. 3003; his son, No. 5470, by his sister; and his grandson, sired by No. 5470 out of an unrelated bird with a good record. The sisters of No. 3003 were noted for very low production in addition to non-broodiness. The average winter egg production of the daughters of No. 3003, as well as of the daughters of No. 4128, another low male of separate origin, is indicated for further comparison.

Graphic representation of the improvement made is shown by integral curves for each year as given in Fig. 6, while frequency polygons for winter egg production for certain years are given in Fig. 7, the statistical constants being given in Table III.

TABLE III. — *Statistical Constants for Certain of the Flocks.*

Year.	Number of Birds.	Mean.[1]	Standard Deviation.	Coefficient of Variation.
WINTER EGG PRODUCTION.				
1913–14	171	36.70± .88	17.05± .62	46.45±2.03
1915–16	237	29.86± .76	17.40± .54	58.27±2.34
1918–19	109	63.61±1.27	19.62± .90	30.85±1.54
1919–20	124	58.56±1.45	23.93±1.02	40.87±2.02
1920–21	160	67.34±1.33	24.88± .94	36.94±1.57
ANNUAL EGG PRODUCTION.				
1913–14	59	145.41±3.04	34.66±2.15	41.06±2.95
1915–16	211	121.21±1.87	40.20±1.32	33.17±1.20
1918–19	64	170.02±2.52	29.89±1.78	43.31±3.03
1920–21	109	200.98±2.57	39.78±1.82	33.15±1.67

[1] Means calculated from grouped data instead of ungrouped as in Table II.

TABLE III. — *Statistical Constants for Certain of the Flocks* — Concluded.

AGE AT FIRST EGG (DAYS).

YEAR.	Number of Birds.	Mean.[1]	Standard Deviation.	Coefficient of Variation.
1913-14	168	255.62±1.13	21.68± .80	48.60±2.17
1915-16	243	263.69±1.50	34.61±1.06	47.61±1.76
1918-19	141	194.58±1.38	24.23± .97	55.60±2.84
1920-21	168	200.44±1.38	26.50± .98	53.61±2.48

[1] Means calculated from grouped data instead of ungrouped as in Table II.

In Fig. 8 certain changes in winter production of selected groups are given, comprising, first, the highest record made in each season by any one individual; second, the best average record made by the daughters of any one mother, provided not less than five daughters comprised the

FIG. 8. — Winter Production.

Broken line, best individual; solid line, best average made by daughters of one female; dotted line, best average made by daughters of one male.

group; and third, the best average record made by the daughters of any one male for each season, provided that he had ten or more daughters.

Changes in Mean Annual Production.

Annual production is the number of eggs laid in the first laying year, beginning with the first egg and running 365 days therefrom. Barring longevity, it is probably the best index of a bird's innate laying capacity.

Reasons for this view have been presented elsewhere. In Table II and Fig. 9 are given the data showing the changes that have taken place. The statements regarding the flocks, as given for winter production, apply here also.

The integral curves for each year will be found in Fig. 10; frequency polygons are given in Fig. 11, the constants in Table III.

Changes in Daily Winter Production.

The daily flow of eggs is a matter of some importance to the commercial poultryman, because of market fluctuations in price. Daily production curves illustrating this flow show some points not brought out in curves plotted on larger time units. The labor of compiling such curves is great, however, unless birds are penned in such a way that the pen record can be used. A few such pen records have been studied and are shown in Figs. 12 and 13 (see pages 116 and 117).

Fig. 9. — Mean Annual Production (Solid Line) and Mean Age at First Egg (Dotted Line).

NB, mean annual production, and N' B', mean age at first egg, for low-broody flock. No annual record for 1919–20. (See page 108.)

The points in all curves calling for particular attention are: the marked irregularity in number of eggs laid on consecutive days; the occurrence of waves of several sorts; the angle of slope of the curve at the beginning of production; the sharp descent from the maximum, due to the winter pause, in the curves of early hatched flocks, and the more gradual rise on recovery, with the marked rise in the curve toward the end of February. The later hatched layers do not exhibit such a sharp decline due to the winter pause. The amount is less and recovery quicker.

Changes in Age at which First Egg is laid.

Early in the history of these experiments it became evident that, on the average, those birds that laid the largest number of eggs before March 1 were those that began laying first. As the average age at which the first egg was laid was eight months, it was evident that either the pullets must be hatched early to get them mature early in the fall, or else they must grow and develop faster. Early maturity, therefore, was made the chief aim of the breeding program, with the results shown in Table II and Fig. 9. Changes in mean date of first egg, Fig. 5, vary directly with changes in mean age at first egg. Integral curves are given in Fig. 14, frequency polygons in Fig. 15 (page 119), and their constants in Table III. Note that

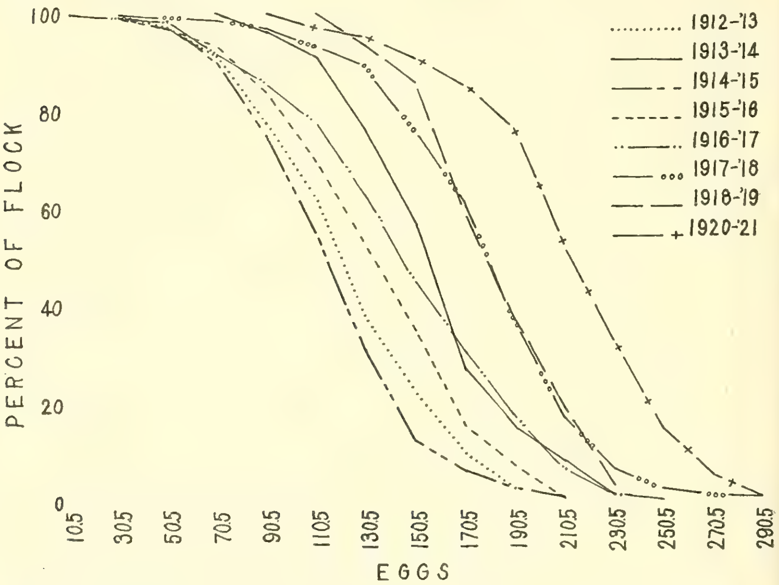

FIG. 10. — Integral Curves showing the Percentage of Each Flock having an Annual Production as Great as that indicated, or Greater.

One zero in 1917-18 is not shown. In 1912-13 no allowance is made for November production as in Table II. The curve for 1913-14 is that of the 59 birds kept through the year. (See Table II.)

apparently something more than a sifting out of an early maturing strain has occurred, as indicated by the mean and range for 1918-19, Fig. 15.

Earlier maturity uncovered, or at least was associated with, more evidence of the winter pause than appeared earlier, so that the gain in production was not as great as was anticipated. As indicated below, progress is being made in reducing the length of the pause, so that, eventually, continuous production throughout the winter is expected.

Since 1917 no attempt has been made to lower the age at first egg. The basis of selection has been the same in each year since 1917. (See

Table I and Fig. 3.) Although there is a fascinating problem involved in attempting further selection for earlier maturity, such an endeavor is not consonant with the main project.

Changes in Length of the Initial Cycle and its Complement, the Winter Pause.

In the station strain of Rhode Island Reds, many individuals produce an initial series of eggs which is followed by a rest period, the winter pause. The trait does not lend itself to ordinary statistical treatment because of its nature, which depends partly on an inherent condition of the strain, and partly on environmental conditions, particularly those

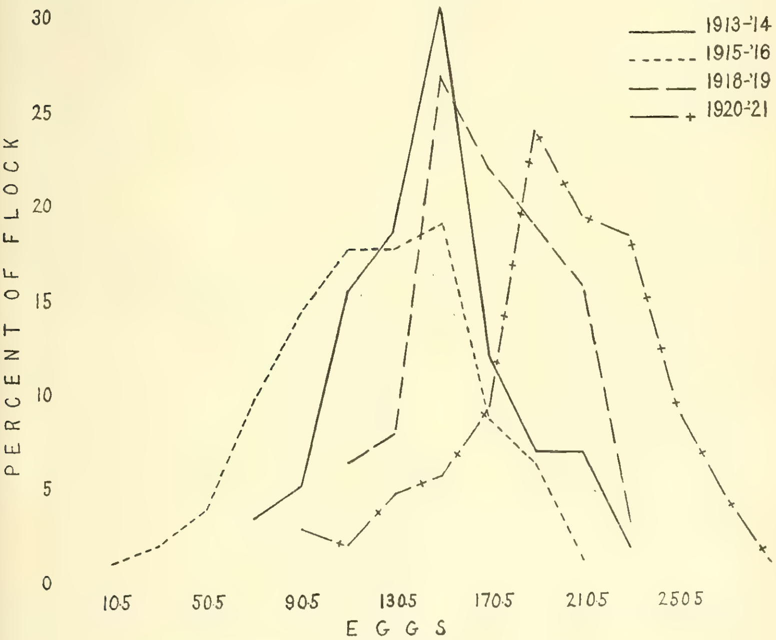

FIG. 11. — Frequency Polygons showing the Percentages of Flocks laying the Given Number of Eggs per Year.

The curve for 1913-14 is that of the 59 birds kept through the year. (See Table II.)

that determine the time of year when the birds begin to lay. Further, it is possible that more than one cycle is involved. The present discussion, therefore, is limited to a general descriptive treatment of the subject, based on experiences with flocks subsequent to those studied in an earlier paper (Goodale, 1918).

It is now clear that the earlier a pullet begins to lay in the autumn, the more likely she is to exhibit the winter pause. A few early layers, however, go through the entire winter without pausing. Roughly speaking, 90 per cent of pullets laying their first egg early in the season (September) ex-

hibit the pause, in contrast to only 30 per cent of those beginning late in the season (December). It is possible that the appearance of the pause is due to some direct effect of the season (length of days, for instance), but since there is no uniformity in the length of the egg-laying period, and since one member of a flock may begin the second laying period at the same moment another is finishing the first, it is clear that whatever influence the environment may exert is secondary, the primary cause being a change in the physiological condition of the layers, expressed in some individuals by an actual pause, in others by a slowing down in production, while in a few individuals no external effect becomes apparent. Note, as shown in Fig. 13, that a flock of late-hatched pullets were laying at a high level at the same time that their early-hatched sisters were in a slump. Clearly it is not the environment alone that is responsible for the pause. Some observations lead to the belief that environmental conditions which

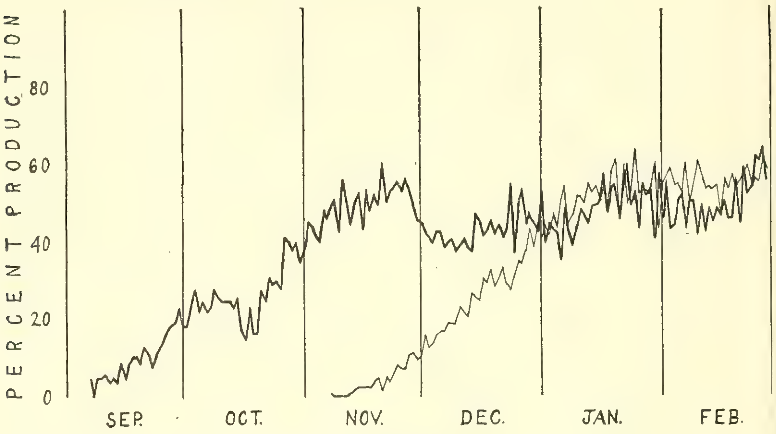

Fig. 12. — Daily Production.
Heavy line 1917–18, Pen III; light line 1913–14. (See text for details.)

at other times would not stop production may do so in this sensitive physiological state. Given an initial (winter) cycle of variable length, it is apparent that in some individuals it may extend into early spring and either overlap the spring cycle and thus fail to become apparent, or perhaps, because of a direct stimulus due to longer days, production may be kept up, and thus the winter pause is suppressed in pullets beginning to lay late in the season.

As far as possible, selection has been directed against the winter pause, and while not eliminated, there is evidence that its length has decreased, and, correspondingly, the length of the initial period increased. This is shown in Fig. 13, where a high production over a period of six weeks was maintained, which is much longer than three years previously, as seen in Fig. 12. The average number of eggs laid, prior to the pause, was 12 more in 1920 than in 1917.

Changes in Amount of Broodiness.

This phase of breeding for increased egg production has been discussed in another place (Goodale, 1920). Here it is sufficient to recall that, while some birds lay continuously throughout spring and summer without any marked slowing in rate of production, others lose much time on account of broodiness, — a loss that very clearly is *not* compensated for.

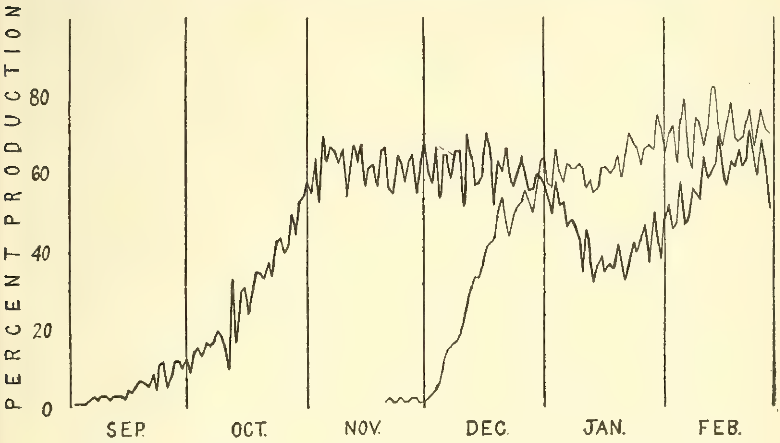

FIG. 13. — Daily Production of Two Pens of the Same Breeding, 1920–21. Heavy line, April hatched; light line, late hatched.

NOTE. — The records of this flock were made under quite different conditions and methods of management from those made by the other flocks. *A priori*, they appeared to be considerably sub-optimal, but the results show that they were at once correct and simple. A brief description of the conditions and methods of management follow.

The 50 females and 6 males were in a pen 22 by 11, 6 feet high at the plate and 10 at the ridgepole, made by stretching wire netting across the south side of a second-story barn floor. A windbreak of paper extended 3 feet from the floor. Roosts were at the west. The main opening was a pitch hole about 4 feet square in the south side. Additional light came from a window 2 feet square in the gable, plus some light from two openings in other parts of the loft. A little sand was put on the floor and straw used as a litter. The birds had water and open boxes of dry mash constantly before them. Oyster shell was fed on the floor. No special grit was fed. Three to 4 pounds of cracked corn were fed in the morning, and double that amount at noon. *Green* sprouted oats *ad libitum* (165 square inches) were fed at noon. Droppings accumulated on the floor back of a wire litter stop. Besides gathering the eggs and keeping straw in the nests and the litter distributed (the latter mostly done by feeding the cracked corn where it was thickest), no other attention was given. The caretaker was away during the day.

The loss due to broodiness is shown when the seasonal production of a broody race is compared with that of a non-broody race. The maximum production of a broody flock comes in March. April is nearly as high, but during May and June, corresponding to the period of progressive increase in the number of broody birds, production declines sharply to a level that either remains nearly constant for July, August and September, or in which the descent is much less marked. (See Fig. 4, 1915–16 and

1918–19.) The highline flock of 1916–17 averaged 105 eggs during the six non-broody months, November to April, while for the six broody months following, May to October, the average was only 70 eggs. Leghorns, on the other hand, continue production at a relatively high level all summer, and first decline sharply in early fall. Kirkpatrick and Card (1917) give data showing a parallelism between degrees of non-broodiness and summer production. The several races, viz., Rocks, Wyandottes, Reds and Leghorns, lay nearly the same number of eggs per bird in March and April and do not differ much in production prior to this date. But during May, June, July, August and September the Leghorns, having the smallest amount of broodiness, lay much more heavily than the other breeds, while the Reds, the most broody race, give the poorest summer production. The Rocks and Wyandottes, which are very much alike in amount of broodiness and intermediate between the Leghorns and Reds, are much alike in their summer production which is intermediate between that of the Reds and Leghorns.

A striking illustration of the loss due to broodiness in an individual bird is shown by B8316, whose egg record is given in Fig. 16. If she had not become broody, but had instead continued to lay through June, July and August at the rate of 26.4 eggs (her average for the seven months preceding), her annual production would have been 306 eggs, 27 more than her actual record of 279 eggs. (The pause in September looks much like a broody period, but she did not stick to the nest, and therefore was not put in the broody coop.)

The first experiment in breeding out broodiness was successful, but at the expense of egg production (Goodale, 1920). The experiment in breeding broodiness out of the high line and still maintaining production is not yet complete, but gives promise of success.

Changes in Date of Last Egg.

The dates of last egg and of first egg determine the length of the annual period. The two limiting dates are treated separately, because it seems probable that date of last egg results from the action of some internal mechanism the nature of which is unknown. While practically all birds are laying from the middle of March to the middle of June, after this, one by one, the birds stop laying, not to resume until next season. The majority, however, continue production till the middle of September, the mean date of last egg being near October 1 in 1914 and 1919. Cessation of production has a genetic foundation, as is indicated by the behavior of various families in this respect, some stopping early and others late. Moreover, many of the best layers show a tendency to continue production indefinitely.

The lack of evidence that the average date of cessation of production has been advanced well into the fall may be associated with lack of especial effort to secure by breeding continued production late into the fall, — an effort that did not seem worth while till after broodiness had been bred out.

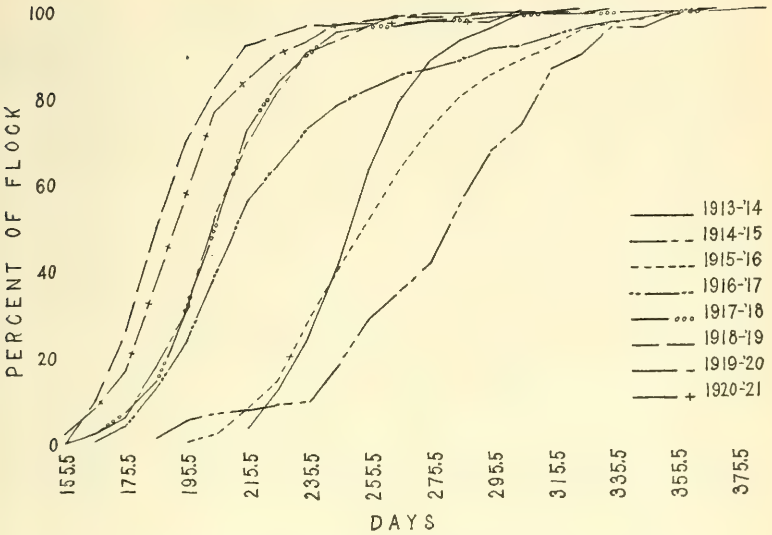

FIG. 14. — Integral Curves showing the Percentage of Each Flock beginning to lay at or before the Ages indicated.

One exceptionally old bird is omitted from 1915–16, and one from 1920–21.

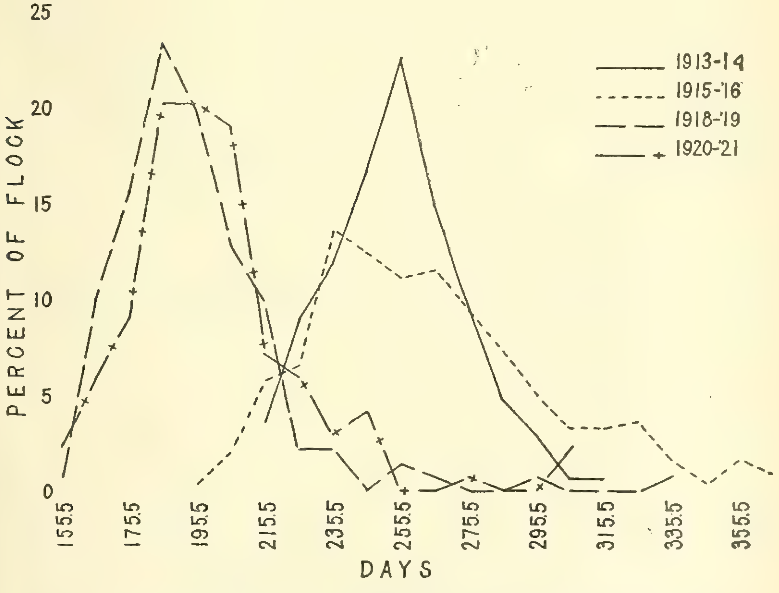

FIG. 15. — Frequency Polygons showing Percentages of Flocks beginning to lay at Ages indicated.

Changes in Rate (Intensity) of Production.

Rate or intensity of production is defined as the number of eggs laid per time unit measured in days. There are several possible time units, such as the month, the initial cycle, the inter-broody periods, the summer period and the spring period. Closely associated with this character is length of clutch, or number of days of continuous (daily) production. Units including well-defined rest periods, such as those due to broodiness or the winter pause, are specifically excluded.

While breeders have been selected, other desiderata permitting, on the basis of high monthly production during the winter, the heterogeneous condition of the flocks in respect to other characters makes comparisons unsatisfactory. The present discussion, therefore, is limited to a comparison of the highest production in any one calendar month before March 1. The use of the calendar month, instead of the highest production for a period of thirty or thirty-one days, although unsuitable in comparing individuals, is sufficiently satisfactory for comparison of flock averages. The average highest monthly production in 1913–14 was 19.28 eggs; in 1920–21 it was 21.10, showing an apparent gain of nearly 2 eggs.

Changes in Seasonal Distribution of Production.

It has been pointed out that the season at which increased production comes may be quite as important as an absolute increase. In addition to winter production, the year may be divided into spring, summer and fall, but differing from the calendar seasons.[1] Spring production includes March, April and May, chiefly because the station statistics show that, regardless of changes at other seasons, the average for these three months (Table IV) has remained nearly constant during these experiments. The period, moreover, is characterized by a sharp decline in mean monthly production from March (sometimes April) to June, due almost wholly to broodiness. A slight increase in mean production for this season has been noted with higher annual production.

[1] Other divisions might be made from the biological standpoint, but such divisions vary from flock to flock and with methods of breeding. The divisions used are approximate and somewhat arbitrary. Further, in studying seasonal distribution, the 365-day limit to a year has been disregarded.

NO. B8316 HATCHED APR. 4, 1920

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
SEP.																																
OCT.																				I	I		I	I	I		I	I		I	I	9
NOV.	I	I	I	I	I	I		I	I	I	I	I		I	I	I	I		I	I	I	I		I	I		I	I		I		24
DEC.	I		I	I		I	I	I		I	I	I	I		I	I	I	I	I		I	I	I	I	I		I	I	I	I		24
JAN.	I	I	I	I		I		I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	27
FEB.	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I				26
MAR.	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	29
APR.	I	I		I	I	I	I			I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		27
MAY	I	I	I	I	I	I	I	I	I	I		I	I	I	I		I	I	I	I	I		I	I	I	I	I	I	I	I	I	28
JUN.	I	I	I	I	I	I	I	I	I		B	R	O	O	D	Y	—						I	I	I	I	I	I	I			16
JUL.		I	I	I	I	I	I	I	I	I	I	I	I		B	R	O	O	D	Y					I	I	I	I	I	I	I	19
AUG.	I	I	I	I	I	I	I	I	I	I	I	I			B	R	O	O	D	Y	—	—				I	I	I	I		I	17
SEP.	I	I	I	I	I	I	I	I	I	I	I	I													I	I	I	I	I	I		18
OCT.	I			I	I	I	I	I	I	I	I	I	I	I	I	I	I															15
NOV.																																

YEAR'S TOTAL 279

FIG. 16. — Egg Record of a Hen, showing the Effect of Broodiness.

TABLE IV. — *Seasonal Distribution of Production.*

YEAR.	Mean Number of Eggs for —						
	November 1 to March 1.	March 1 to May 1.	March 1 to June 1.	November 1 to May 1.	May 1 to November 1.	June 1 to October 1.	Year, November 1 to November 1.
1912–13	28.73	34.54	50.66	63.27	50.98	34.86	114.25
1913–14	36.34	33.17	47.13	69.51	54.12	40.16	123.63
1915–16	30.40	36.24	51.79	66.64	55.16	39.61	121.80
1916–17	41.39	38.15	53.60	79.54	52.91	37.46	132.45
1917–18	55.95	37.90	52.96	93.85	68.96	53.90	162.81
1918–19	56.07	38.36	55.61	94.43	67.58	50.33	162.01
1919–20	51.07	34.90	50.50	85.97	–[1]	–[1]	–[1]
1920–21	62.34	42.65	63.30	104.99	90.37	60.67	195.36

[1] Records stopped June 1. See p. 108.

Summer production includes June, July, August and September. The sharp decline previously noted is checked, and the mean monthly production declines much more gradually from month to month till October. Some years the decline is less than others (see Table V). The decline during the summer is due to the completion of the annual cycle on the part of some individuals, the first cases occurring in June, and to some slackening in rate (intensity). As shown in Table IV, there has been some increase in

TABLE V. — *Decrease in Mean Monthly Production from Highest Monthly Mean (March or April) to June, and from June to September.*

YEAR.	Mean Production.					
	Greatest Monthly.	June.	Difference.	June.	September.	Difference.
1913–14	M. 17.17	10.75	6.42	10.75	7.74	3.01
1915–16	M. 18.56	12.26	6.30	12.26	6.67	5.59
1916–17	M. 19.41	10.62	8.79	10.62	6.98	3.64
1917–18	M. 20.66	13.28	7.38	13.28	10.69	2.59
1918–19	A. 19.78	14.56	5.22	14.56	8.86	5.70
Average for five years .	19.12	12.29	6.82	12.29	8.19	4.11

summer production in the high line over the earlier years. It is believed that the elimination of broodiness will be the main factor in securing further increase of production during these months.

Fall production includes October, overlapping into the following months and thus the next calendar year. It is the season of completion of the annual cycle on the part of most individuals. There is a considerable tendency for the best layers to keep producing, and, as their numbers have increased, it has been reflected in somewhat higher average production during this period.

Changes in Variability.

As shown by both the standard deviation and the coefficient of variation[1] (Table III), and by the several frequency polygons (Figs. 7, 11 and 15) for winter egg production, annual production and age at first egg, there has been no especially significant lessening of variability as a result of selection. Selection has merely moved the frequency polygon to one side without changing its general character.

Influence of Changes in Sanitary Methods.

The work was commenced on the basis of the best poultry practices available, but the sanitary measures proved wholly inadequate, and suitable methods had to be developed. There are, however, sufficient checks, indicated especially in Fig. 5, which show, with the exceptions noted in the next paragraph, that fundamentally the changes in production are due to breeding.

The low mean production of 1912–13 is due in part to late hatching. Other factors can only be guessed at. The low production of 1914–15 is probably due to improper methods of brooding plus disease and poor help.

Recommendations.

It is difficult, at present, to lay down a series of recommendations that can be followed by breeders, with a guarantee that they will work in every case. The following recommendations, based on experience, are intended only for the man who is prepared to go to the necessary expense, time and trouble.

A. Prerequisites.
1. Proper management, including housing, feed, sanitation.
2. Maintenance of vigor. It is true, hens of poor vigor are sometimes good layers, but good vigor as a rule is essential.
3. (*a*) Careful trapnest egg records.
   (*b*) Careful pedigree records.
4. A good understanding of both desirable and undesirable egg production characteristics in the flock to be improved.
5. Families of at least seven pullets.
6. Pullets hatched between March 25 and May 15.

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[1] The coefficient of variation, if calculated according to the usual formula C. V. $= \frac{\sigma}{M} \times 100$, is a poor index of the real variability, since the range of the polygon does not begin at zero. It is obvious that the formula C. V. $= \frac{\sigma}{M-X} \times 100$, where X is the lower end of the range, is a better index of variability. This is the formula used for age at first egg and for annual production in Table III.

B. Method.

The flock is to be improved by degrees, taking one desirable character at a time and making sure that it is well established in the flock as a whole before concentrating on a second.

In order to be as specific as possible, the following detailed outline is given: —

First Step. — Get the flock so that the pullets will mature before 200 days of age, by choosing as breeders those that mature before that age. The males must be from hens of the same qualifications, or brothers to those families of pullets that give the greatest percentage of qualifying females.

Second Step. — Choose as breeders birds that mature right and which are not broody. This step is not necessary for Leghorns.

Third Step. — As soon as a sufficient percentage of the flock — say 50 per cent — qualifies in these two respects, make the breeders qualify in three characters. Require them to mature before 200 days of age; to be free from broodiness; and to lay 22 eggs in either November or December.

Fourth Step. — As soon as enough birds qualify, make the breeders qualify in still another point, so that the qualifications become: first egg before 200 days of age; not broody; 22 eggs in November or December; not less than 80 during the winter, and continuous production for at least twelve months. At this point, if the breeder so desires, egg size, color or other characters may be added to the qualifications required of breeders, or he may aim for still better production.

Only those females should be used a second time, at least with the same male, some of whose progeny make an advance over the parent, unless the family as a whole is better than the average of the preceding generation. On the other hand, any pairing that gives superior results may be repeated year after year, or until something better has been obtained.

It should be pointed out that the larger the flock trapnested, the more rapid should be the progress made, for with a flock of two to three thousand pullets under the trapnest, it should be possible to pick out 30 to 40 birds that when tested will give ten or fifteen breeders of proven ability. These, if properly handled, should make possible very rapid progress.

Summary.

1. A description of changes in various phases of egg production is given.

2. Both mean winter and mean annual egg production have increased.

3. The age at which the first egg is laid has been reduced.

4. Progress in eliminating both the winter pause and broodiness is shown.

5. Provisional recommendations for improving egg production by breeding are given.

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BULLETIN No. 212.

DEPARTMENT OF AGRICULTURE.

A THIRTY-YEAR FERTILIZER TEST.

BY SIDNEY B. HASKELL.

History of Plots.

In February of 1889 Dr. W. O. Atwater, then director of the Office of Experiment Stations of the United States Department of Agriculture, issued a call for a conference to consider and adopt if practicable a uniform method of conducting what were then called soil tests. As a result of this call a conference was held in Washington, this Station being represented by Professor Wm. P. Brooks. A method of testing the soil by means of comparative field plots was decided upon, and in Massachusetts a number of such tests were instituted. Two of these were on the Station grounds, — the South Soil Test started in 1889 and the North Soil Test in 1890. Nine similar tests were laid out in other parts of the State. The object was "to find out the particular fertilizer requirements of the soils of different localities;" and in the letter sent out arranging for the co-operative tests, the statement was made that "the best soil for the purpose is one which represents best the average conditions in your county, which is level or of uniform moderate slope, of uniform and low fertility, and now in grass."

Up to and including 1917 these soil tests were under the supervision of Dr. William P. Brooks, formerly agriculturist and later director and agriculturist of the Experiment Station. Progress reports under the authorship of Dr. Brooks were made in Bulletins Nos. 9, 14, 18 and 58 of the Hatch Experiment Station, and likewise in the annual reports of that Station and its successor, the Massachusetts Agricultural Experiment Station. Records from these tests, with analysis and discussion, were also published in "Das Nährstoffbedürfnis Verschiedener in Fruchtfolge auf demselben Felde Angebauter Pflanzen nach Versuchen in Massachusetts, Nordamerika," presented by Dr. Brooks at the University of Halle, Germany, as a doctorate dissertation.

The greatest service of these field tests to date has probably been the establishment of the fact that individual crops vary widely in their plant food requirements, and that fertility practice may be affected more by

the kind of crop than by the type of soil on which it is grown. Dr. Brooks presented this idea in his summarization of these experiments published in Bulletin No. 58 above cited, and was one of the first, if not the first, of the fertility workers of the country to observe this fact. Results secured during the score of years which has elapsed since the observation was first made have confirmed the conclusion in abundant measure.

The South Soil Test.

This test is on a soil classified in the soil survey of the Connecticut Valley as a Merrimac coarse sandy loam. The field is practically level, and had been in grass without manure for five years previous to the laying out of the test. Earlier still, for an unknown number of years, it had been in pasture.

Cropping System.

The original plan was apparently that of a five-year rotation, consisting of two years of corn, then a grain crop, followed by two years of grass and clover. This plan, however, was not followed consistently, although, in the thirty years of which we have full record, thirteen corn crops were grown. A complete list of crops as grown year by year is contained in Table I of the Appendix.

Fertilizer Treatment.

The fertilizer treatment is shown in the following schedule: —

Plot.	Fertilizer.	Pounds per Acre.
1	Nitrate of soda	160
2	Dissolved boneblack	320
3	Nothing.	
4	Muriate of potash	160
5	Lime	800
6	Nothing.	
7	Manure	30,000
8	Nitrate of soda Dissolved boneblack	160 320
9	Nothing.	
10	Nitrate of soda Muriate of potash	160 160
11	Dissolved boneblack Muriate of potash	320 160
12	Nothing.	
13	Plaster	800
14	Nitrate of soda Dissolved boneblack Muriate of potash	160 320 160

The plots were 18 by 121 feet in size, or exactly one-twentieth of an acre. A strip 3 feet wide between plots was cultivated as though a part of the adjacent plots, but yields on these strips were never recorded.

Lime History.

Lime was applied in the following amounts: —

Year.		Pounds per Acre.
1899.	Slaked lime	2,000
1904.	Slaked lime, about	3,000
1907.	Agricultural lime, about	1,000
1909.	Agricultural lime	2,000
1916.	Ground limestone	4,000

Precipitation and Frost Records.

Tables II and III in the Appendix show the observations on temperature, frost and precipitation as taken by the Department of Meteorology of the Experiment Station for the years from 1889 to 1921, inclusive.

During this thirty-three-year period there have occurred certain fairly definite weather cycles. For a period of eight years, 1897 to 1904, inclusive, the annual rainfall was consecutively above the mean for the period. From 1907 to 1914, inclusive, with the exception of a single year, the annual precipitation was below the mean of the period, and averaged 10 inches annually below that of the preceding period. From 1907 to 1913 the rainfall of the growing season, April to August, inclusive, averaged 14.7 inches; while for the succeeding seven years the average for the same period was 20.3 inches. There were also in the whole period wide extremes in total precipitation, the least being 10.82 inches for the growing period in 1894, and the highest 32.25 inches in 1892. The growing season, or the time between the last killing frost of the spring and the first killing frost of autumn, varied from 99 days in 1894 to 164 days in 1920. With such wide variations in weather conditions, especially as regards the dominant influence of precipitation, temperature and length of season, it is not to be expected that results from fertilizer use would in all cases be as expected, or show records always consistent one with the other.

Yields.

A complete statement of yields is given in Table I of the Appendix. Corn was grown more often than any other single crop, there having been a total of thirteen corn crops. For two years preceding the eleventh crop, however, the land was practically fallow; while the twelfth and thirteenth crops followed partial or total crop failures. The best picture of results, therefore, may be obtained by considering the corn crop as the common denominator of all the crops, and dividing the corn yields into three periods, including the first five crops in the first, the second five in the second, and the last three somewhat abnormal crops in the third, as shown in Table 1: —

TABLE 1. — *The Corn Crops.*

Grain (Average Yields per Acre, Bushels).

Plot.	Treatment.	First Period.	Second Period.	Third Period.
1	Nitrate of soda	26.73	6.05	26.55
2	Dissolved boneblack	23.96	4.52	13.03
3	Nothing	20.74	4.31	10.97
4	Muriate of potash	44.61	31.83	44.79
5	Lime	23.71	2.81	9.26
6	Nothing	20.79	5.27	11.08
7	Manure	63.11	57.20	56.13
8	Nitrate of soda Dissolved boneblack	32.33	9.84	–[1]
9	Nothing	25.37	5.53	–[1]
10	Nitrate of soda Muriate of potash	42.07	35.38	43.85
11	Dissolved boneblack Muriate of potash	54.90	39.33	44.53
12	Nothing	23.10	7.50	20.43
13	Plaster	27.09	9.14	14.54
14	Nitrate of soda Dissolved boneblack Muriate of potash	62.46	41.89	38.52

[1] These plots were discontinued in 1911.

These results are presented in graphic form in Fig. 1, arranged to show the total yields of grain and stover, and likewise the comparative yields in the two five-year periods. It will be noted that the yield of grain decreased very materially and significantly in the second five-year period. In all of those plots to which potash treatment was applied, the yield of stover did not decrease in like measure. On the other hand, where potash was not applied, the decrease in the yield of stover was somewhat similar in its significance to the decrease in grain. In all cases, the number of pounds of stover produced per bushel of grain was larger in the second period than in the first, and very materially so in the no-potash treatments.

The First Ten Corn Crops.

The Check Plots. — The significance of the results and their interpretations may best be judged on the basis of the yields on the check plots. There were four such plots, numbered respectively, 3, 6, 9 and 12. The following table shows the yields of corn divided into two five-year periods. Under the system of farming followed, the yielding power of the untreated soil was very low. The acre yields in the second period were practically zero. The check plots were, however, fairly uniform in production.

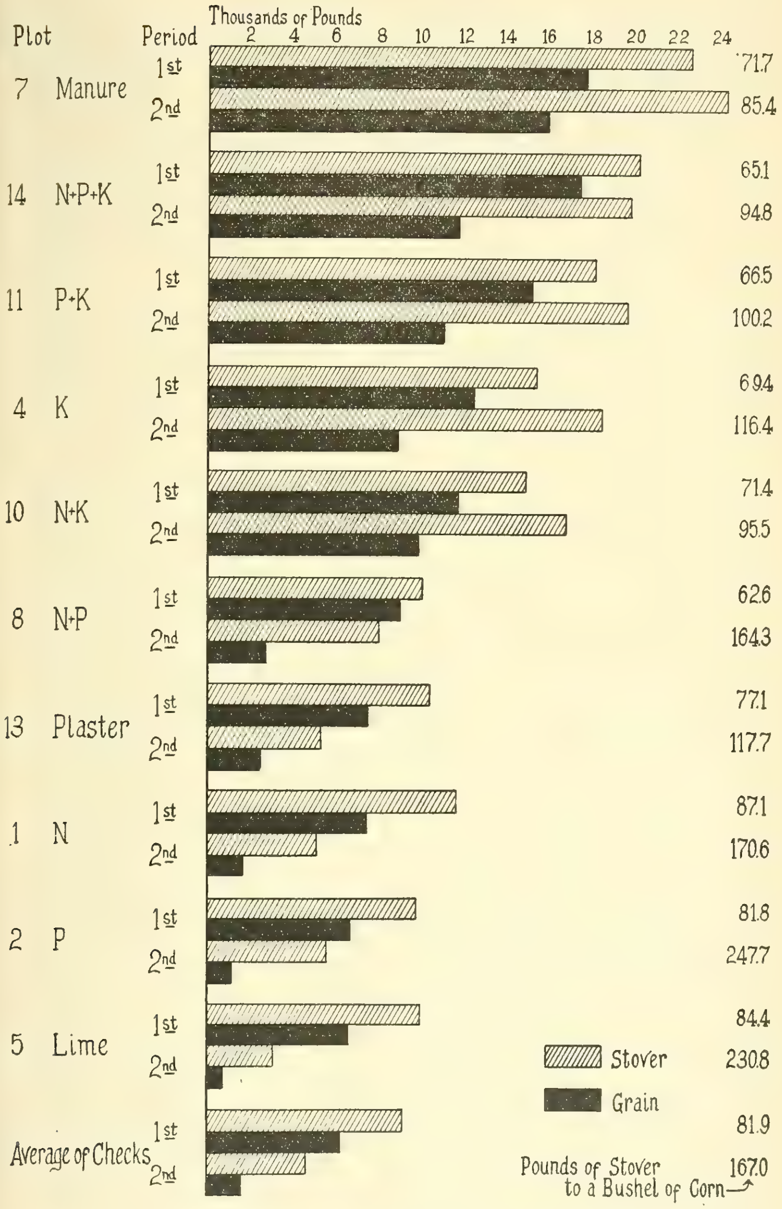


FIG. 51. — South Soil Test. Total yields per acre. Ten corn crops.

TABLE 2. — *The Check Plots.*

Plot.	Corn (Bushels per Acre). First Period.	Second Period.	Decrease.
3	20.74	4.31	16.43
6	20.79	5.27	15.52
9	25.37	5.53	19.84
12	23.10	7.50	15.60

The Effect of Potash. — The most marked and most striking result of the test, especially as indicated by the corn crop, was the great response to potash. The following table shows the average yields of corn for the two periods under discussion for those treatments which include this plant food: —

TABLE 3. — *The Treatments containing Potash.*

Plot.	Treatment.	Corn (Bushels per Acre). First Period.	Second Period.	Decrease.
4	Muriate of potash	44.61	31.83	12.78
7	Manure	63.11	57.20	5.91
10	Nitrate of soda Muriate of potash	42.07	35.38	6.69
11	Dissolved boneblack Muriate of potash	54.90	39.33	15.57
14	Nitrate of soda Dissolved boneblack Muriate of potash	62.46	41.89	20.57

Potash alone was effective, although the difference between the first period and the second period is very large. This treatment outyielded the potash and nitrogen treatment in the first period, but results were reversed in the second.

The use of a mineral plant-food ration consisting of phosphoric acid and potash gave marked results. Here again, however, the decrease in yield between the two periods was fully as great as, in fact somewhat larger than, the decrease on either the potash or potash and nitrogen plots. On the complete fertilizer, however, the decrease was even greater; for whereas this treatment was definitely superior in yield during the first period, it was very little better than the phosphoric acid and potash treatment in the second.

There are two explanations for this apparent decrease in yielding power in the two periods under discussion. The weather conditions may not

have been the same for the two series of corn years; and the destructive system of farming followed may have seriously affected the ability of the soil to produce crops on fertilizers alone, as compared to its ability to produce crops on barnyard manure.

With reference to the first possibility, Table 6, page 136, presents data for moisture and temperature during all of the years in question. An attempt is made to epitomize these records in a single sentence descriptive of the growing conditions for the years in question. Bringing these together, the following picture is obtained of the comparative growing conditions in the two periods: —

First Period.		*Second Period.*	
1889.	Warm and moist in the early season.	1902.	Cool with abundant moisture.
1890.	Normal.	1903.	Drought in May; very cold and wet in June; very cold in August.
1894.	Warm and generally dry following a dry winter.	1904.	Wet spring; cool.
1898.	Good growing season.	1907.	Cold and dry following a dry winter.
1899.	Slight moisture deficiency.	1910.	Drought.

It is evident that the weather conditions in the last period were less favorable than in the first period.

In interpreting the significance of the above facts, thought must be given to the farming system followed. At the very beginning the stage was apparently set, although unconsciously, for a crop increase from the use of fertilizer potash. Grass, a heavy potash feeder, had been occupying the land for a number of years, but without return to the soil of either manure or fertilizer. As the years passed, this initial condition was accentuated through the removal from the soil of successive crops of corn and of grass and clover. Had these crops been fed on the farm, as in practical agriculture they must have been, there would have been potash return to the soil by natural means and less need for the use of commercial potash.

The Destructive Treatments. — A number of treatments were definitely destructive, *i.e.*, yields decreased definitely and significantly from one period to another, and reached a point at which profitable farming would have been absolutely impossible. Nitrate of soda alone, acid phosphate alone, lime alone, nitrate of soda and acid phosphate, and land plaster come in this list. The average yields for the first and second periods for plots treated with these materials were as follows: —

Table 4. — *The Destructive Treatments.*

Plot.	Treatment.	Corn (Bushels per Acre). First Period.	Second Period.	Decrease.
1	Nitrate of soda	26.73	6.05	20.68
2	Dissolved boneblack	23.96	4.52	19.44
5	Lime	23.71	2.81	20.90
8	Nitrate of soda Dissolved boneblack	32.33	9.84	22.49
13	Plaster	27.09	9.14	17.95

Since the farming system followed was one which logically and on many soils inevitably results in need of complete fertilizer applied in large quantities, it is not astonishing that the one-sided treatments should give such poor results.

It will be noted that the above-mentioned destructive treatments are those which contain no potash, which fact is of importance in connection with the lime history of the field. Commencing in 1899, lime was applied at frequent intervals, and in generous quantity. It has sometimes been claimed that such use of lime makes soil potash available. Did it have such an effect, it would be expected that the yields on the nitrate of soda, the dissolved boneblack (acid phosphate) and the nitrate and boneblack plots would approximate those secured on equivalent treatments with potash added. This expectation has not been realized. There is no indication in the data at hand that lime has had any measurable or significant effect in increasing the availability of soil potash.

Manure versus Fertilizer. — Table 5 shows the comparative corn yields year by year, with averages for the two periods in question, of Plot 7, receiving manure, and Plot 14, receiving complete fertilizer.

Table 5. — *Comparison of Manure and Complete Fertilizer.*

First Period. Year.	Corn (Bushels per Acre). Plot 7, Manure.	Plot 14, Complete Fertilizer.	Second Period. Year.	Corn (Bushels per Acre). Plot 7, Manure.	Plot 14, Complete Fertilizer.
1889	57.50	61.50	1902	68.70	56.20
1890	59.75	71.00	1903	37.39	25.56
1894	54.70	51.00	1904	50.00	47.78
1898	67.70	55.90	1907	72.50	38.31
1899	75.90	72.90	1910	57.43	41.57
Average	63.11	62.46	Average	57.20	41.89

For the first five crops the two treatments gave practically the same results. For the last five crops, yields were maintained fairly well by the manure treatment, and not at all well on the fertilizer treatment. This difference in plot behavior may be explained, in part, either by the fact that manure contained organic matter while the fertilizer used did not, or by the difference in plant food. The amounts of plant food applied per acre in the two contrasted treatments are as follows: —

	Pounds per Acre (Average per Year).	
	Applied in Manure.	Applied in Fertilizer.
Nitrogen	108	24
Phosphoric acid	118	51
Potash	169	80

The amount of manure used is larger than could have been produced had all crops grown been fed to animals and all of the manure produced carefully saved and returned to the land. For this reason the fact brought out in the foregoing table has no great significance in its bearing on actual practice.

Response of Corn to Fertilizer Nitrogen. — There was wide variation in the degree of response of the crop to the use of fertilizer nitrogen. In two cases there was apparently a significant decrease in crop produced by such use, — a result which, while unusual, is by no means impossible. Owing to its favorable effect on nitrification, corn seldom shows marked response to the use of this plant food except under those conditions where the soil supply of organic nitrogen is very limited. Less response would therefore be expected on the corn crops following legumes or grown on sod than on the corn crops following non-legumes or grown on stubble, while the greatest increase would be expected from those corn crops which are three years from a legume.

The following tabulation was made to see if this expectancy be supported by facts. Owing to the comparatively small variation in checks, the yields on the phosphoric acid and potash plot are compared directly with those on the complete fertilizer plots. The yields on the manure plots are included, as significant of results secured where there was a sufficiency of plant food and organic matter in the soil. Since moisture and temperature conditions influence nitrification, the departure from normal of both precipitation and mean hourly temperature is tabulated alongside the yield records.

TABLE 6. — *Relationship between Increase from Fertilizer Nitrogen, Place in Rotation and Weather Conditions.*

CORN, YIELDS PER ACRE, SOUTH SOIL TEST.

I. *Following Legume or "Old Sod."*

[The first row of figures under the date line is bushels of corn per acre; the second row, pounds of stover per acre.]

Precipitation (Inches). Above Normal.		Precipitation (Inches). Below Normal.	Manure.	Phosphoric Acid and Potash.	Nitrogen, Phosphoric Acid and Potash.	Mean Hourly Temperature (Degrees Fahrenheit). Above Normal.		Mean Hourly Temperature (Degrees Fahrenheit). Below Normal.
			1889.					
	April	—0.84	57.50	58.00	61.50	+3.2	April	
+1.03	May		4,200	3,960	4,180	+4.0	May	
+1.63	June		Warm and moist in early season.			+2.0	June	
+6.11	July						July	—1.1
	August	—1.53					August	—2.5
			1894.					
	April	—1.42	54.7	49.5	51.0	+1.8	April	
+0.32	May		3,760	3,820	3,780	+1.3	May	
	June	—0.25	Warm and generally dry following a dry winter.			+3.7	June	
	July	—2.86				+2.9	July	
	August	—3.94				+1.3	August	
			1902.					
+0.05	April		68.7	55.9	56.2	+1.2	April	
	May	—1.36	6,220	4,640	4,540		May	—0.4
+1.16	June		Cool and abundant moisture.				June	—2.2
+0.25	July						July	—2.8
+0.40	August						August	—1.9
			1907.					
	April	—1.28	72.50	30.13	38.31		April	—4.6
+0.34	May		6,900	6,500	5,500		May	—5.6
	June	—1.02	Cold and dry following a dry winter.				June	—1.8
	July	—0.54					July	—0.6
	August	—2.81					August	—1.9
			1913.					
+0.04	April		66.8	49.7	44.4	+1.5	April	
+1.26	May		5,140	4,040	3,840		May	—1.8
	June	—2.48	Dry from June on.			+0.7	June	
	July	—2.82				+0.8	July	
	August	—1.99				+1.5	August	
			1915.					
+0.73	April		60.79	37.58	35.15	+3.8	April	
	May	—2.48	3,520	3,250	3,400		May	—3 3
	June	—0.38	Cool, with flood conditions in late season.				June	—1.5
+4.72	July						July	—1.7
+4.03	August						August	—2.0
			1917.					
	April	—1.43	40.8	46.3	36.0		April	—3.2
+0.45	May		5,200	3,300	5,400		May	—8.1
+1.89	June		Very cool in early season.				June	—0.4
	July	—1.05				+1.1	July	
+2.81	August					+2.9	August	

TABLE 6. — *Relationship between Increase from Fertilizer Nitrogen, Place in Rotation, and Weather Conditions* — Continued.

CORN, YIELDS PER ACRE, SOUTH SOIL TEST — *Concluded.*

II. *Second Year after Legume or Sod.*

Precipitation (Inches). Above Normal.		Precipitation (Inches). Below Normal.	Manure.	Phosphoric Acid and Potash.	Nitrogen, Phosphoric Acid and Potash.	Mean Hourly Temperature (Degrees Fahrenheit). Above Normal.		Mean Hourly Temperature (Degrees Fahrenheit). Below Normal.
			1890.					
	April	—1.53	59.75	65.90	71.00	+0.4	April	
+1.71	May		5,520	4,880	5,320		May	—0.3
	June	—1.85	"Normal."				June	—0.4
+1.22	July						July	—0.8
+0.63	August						August	—0.8
			1898.					
+0.47	April		67.7	41.2	55.9		April	—3.1
+1.93	May		3,800	2,440	2,600		May	—1.8
+0.31	June		Good growing conditions.			+0.3	June	
+0.32	July					+0.3	July	
+2.60	August					+1.7	August	
			1903.					
	April	—0.96	37.39	20.39	25.56	+0.8	April	
	May	—3.20	3,600	2,320	3,040	+1.8	May	
+4.41	June		*Drought in May;* very cold and wet in June; very cold in August.				June	—6.1
+0.23	July						July	—1.7
+0.67	August						August	—6.0
			1910.					
	April	—0.19	57.43	37.14	41.57	+4.5	April	
	May	—1.01	3,700	2,300	3,080		May	—1.3
	June	—0.73	Drought.				June	—1.9
	July	—2.51				+1.5	July	
	August	—0.22					August	—0.9

III. *Third Year after Legume or Sod.*

			1899.					
	April	—1.47	75.9	59.9	72.9		April	0
	May	—2.40	5,350	3,160	4,450		May	—1.7
+0.75	June		Slight moisture deficiency.			+1.7	June	
+0.48	July						July	—0.5
	August	—2.25					August	0
			1904.					
+2.47	April		50.00	53.11	47.78		April	—3.6
+0.87	May		4,000	3,940	3,700	+2.7	May	
+1.97	June		Wet spring; cool.				June	—0.7
	July	—1.79					July	—0.8
	August	—0.16					August	—1.6

TABLE 6. — *Relationship between Increase from Fertilizer Nitrogen, Place in Rotation, and Weather Conditions* — Concluded.

CORN, YIELDS PER ACRE, NORTH SOIL TEST.

I. *Following Legume or Sod.*

Precipitation (Inches).			Manure.	Phosphoric Acid and Potash.	Nitrogen, Phosphoric Acid and Potash.	Mean Hourly Temperature (Degrees Fahrenheit).		
Above Normal.		Below Normal.				Above Normal.		Below Normal.
				1890.				
				Whole Plot.				
	April	—1.53		74.0	74.9	+0.4	April	
+1.71	May			5,740	5,820		May	—0.3
	June	—1.85		"Normal."			June	—0.4
+1.22	July						July	—0.8
+0.63	August						August	—0.8
				1905.				
				Limed.				
	April	—0.70		34.24	43.06		April	—0.5
	May	—2.40		3,400	4,840		May	—0.5
	June	—0.52		Cool and very dry.			June	—1.3
	July	—1.78				+0.5	July	
+2.22	August						August	—2.2
				Unlimed.				
				11.29	36.24			
				4,520	5,840			
				1916.				
				Limed.				
+0.43	April			48.1	41.2		April	—2.2
	May	—0.47		4,000	4,200		May	—1.5
+1.96	June						June	—4.6
+2.44	July					+1.0	July	
	August	—1.76				+1.5	August	
				Unlimed.				
				30.3	38.3			
				2,500	4,200			

In the year following a legume there has been no consistent response of the crop to the use of fertilizer nitrogen, and this almost without regard to the condition of the weather. The second year after a legume, however, there has been such response, — in one case in a marked degree. In the two cases where corn was planted three years after the legume, one showed an apparent increase rather significant in size, the other an apparent decrease.

For comparison, the results of the three corn crops grown on the North Soil Test are presented. All of these were grown after sod or legume. On the limed section or on the undivided plot, nitrogen brought a crop increase in one case out of three. On the unlimed section, in the two years of record, there was a definite increase. This result may trace back to the poor growth of the clover on the unlimed land.

The Last Three Corn Crops.

Cultural methods from 1909 on departed widely from the normal. In 1908 a catch crop of crimson clover was turned under as a green manure. In 1909 a partial crop of buckwheat was turned under. In 1911 there was

a cultivated fallow, and in 1912 something which in its effect was practically a fallow. The 1913 corn crop therefore had the benefit of two years of soil idleness. In 1914 a crop of soy beans failed to mature, and hence presumably left more of value in the stubble than would have been the case had the crop ripened its seed. In 1916 sweet clover was sown, but the crop appeared to be mostly weeds. This was cut and removed from the soil but not weighed. The corn crops of 1913, 1915 and 1917 therefore are not comparable with the earlier crops, although they may indicate the fertility tendencies as brought about by this abnormal treatment.

The Hay Crops.

There were six crops of grass and clover. One of the most marked results in the whole history of the experiment was the character of the vegetation produced by differential fertilizer treatment on uniform seeding. Clovers failed to grow where potash was not applied. The effect of this is shown primarily in the rowen crop, which consisted largely of clover. The number of hay crops was, however, too small and the crop too responsive to varying weather conditions to admit of any very satisfactory interpretation of the data. The graphic presentation (Fig. 2) represents the total yields for the six crops.

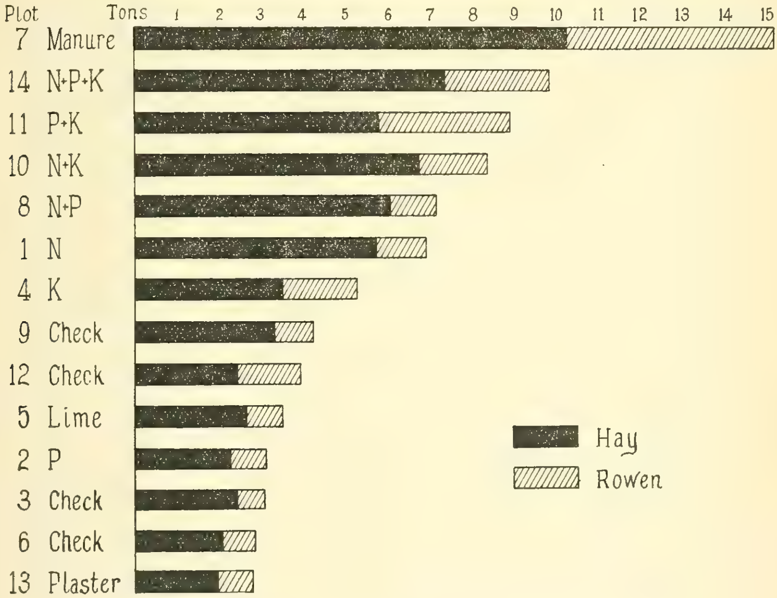


FIG. 2. — South Soil Test. Total yields per acre. Six hay crops.

Financial Interpretation.

No satisfactory financial interpretation of the results of the experiment is possible. Fertilizers were applied according to a set schedule, without reference to the value of the crop or to its ability to make payment through increased acre value for the plant food applied. Neither was there any attempt to estimate the necessity of one plant food or another as indicated by the previous history of the plots, and response of the crops grown to varying fertility treatments.

The North Soil Test.

History.

This field was started in 1890. Previously it had been pasture, without definite manure application, for a number of years. The plots are located about 150 yards from the South Soil Test, and are on soil of the same formation, although with a more definite slope toward the west. Fig. 3 shows the shape and arrangement of plots as compared with the South Soil Test.

Fertilizer Treatment.

The fertilizer treatment was the same in principle as that on the South Soil Test, except that the plots were differently laid out and hence bore different numbers. The schedule follows: —

Plot.	Treatment.	Pounds per Acre.
1	No fertilizer.	
2	Nitrate of soda	160
3	Dissolved boneblack	320
4	No fertilizer.	
5	Muriate of potash	160
6	Nitrate of soda Dissolved boneblack	160 320
7	Nitrate of soda Muriate of potash	160 160
8	No fertilizer.	
9	Dissolved boneblack Muriate of potash	320 160
10	Nitrate of soda Dissolved boneblack Muriate of potash	160 320 160
11	Plaster	800[1]
12	No fertilizer.	

[1] 1892–95, 160 pounds per acre; 1896, increased to 400 pounds per acre; 1902, increased to 800 pounds per acre.

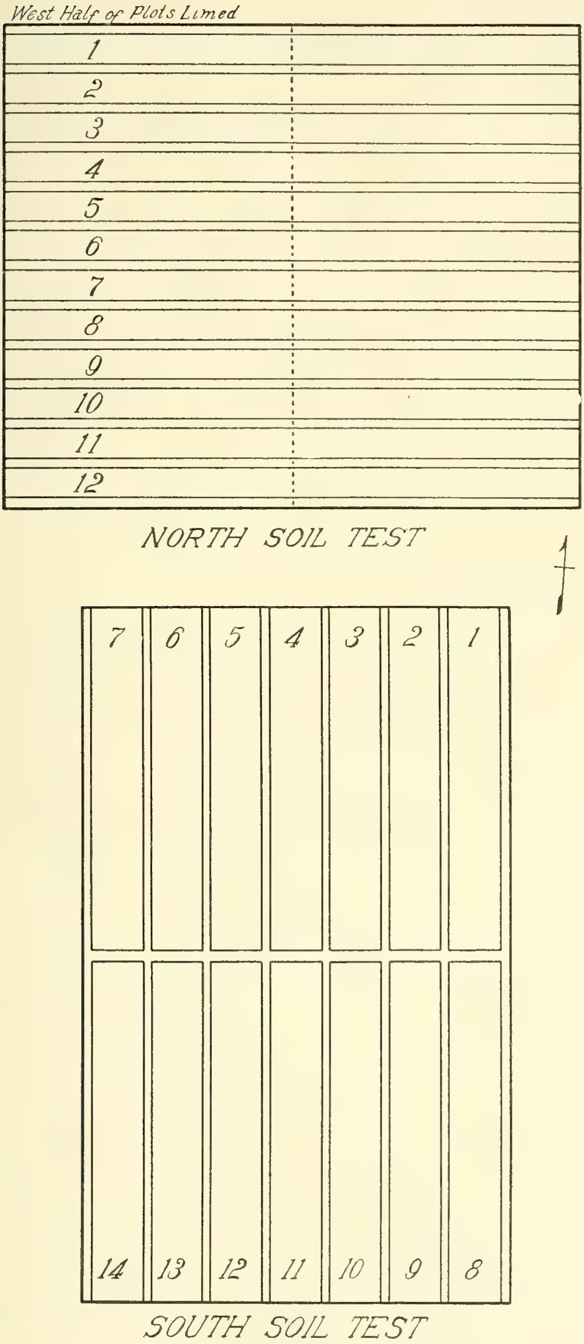


Fig. 3. — Plan of the plots.

In 1897 and 1902 for potatoes, in 1898, 1899, 1900 and 1901 for onions, and in 1903 and 1904 for grass and clover, the fertilizer applications were doubled. In 1899 lime was applied to the west half of the field, and was repeated in 1904, 1907 and 1916, a total of 4½ tons per acre of lime in one form or another being applied over a period of eighteen years.

Table IV of the Appendix gives the record of yields over the period of the experiment.

Variation in Checks.

The check plots were very variable. The yields of grass and clover on the limed and unlimed halves of the field illustrate this fact.

TABLE 7. — *Grass and Clover Yields on Check Plots (Yields per Acre, Pounds).*

Year.	Unlimed.				Limed.			
	Plot 1.	Plot 4.	Plot 8.	Plot 12.	Plot 1.	Plot 4.	Plot 8.	Plot 12.
1903	360	**550**	450	420	**1,150**	1,010	570	1,140
1904	**1,200**	590	600	650	880	690	1,440	**1,520**
1908	**1,340**	780	480	440	2,160	1,560	1,640	**2,220**
1909	**1,280**	1,180	1,150	720	**1,570**	1,520	1,560	1,520
1914	**1,600**	1,240	820	600	1,840	2,030	2,920	**3,060**
1915	920	**1,020**	520	480	1,480	2,220	2,320	**2,940**

The highest yielding plots in each year are bold-faced type.

Plot 1 on the limed and unlimed portions of the field is seemingly superior, at least in its ability to grow grass and clover, to Plots 4 and 8. Plot 12, unlimed, is the poorest of the checks, while on the limed portion of the field it is superior to Plot 1. Owing to this variation in different parts of the field, the data presented in Table IV of the Appendix do not permit of clear-cut numerical discussion. They serve to indicate tendencies rather than to furnish statistical proof. It is probable, also, that the natural variation in the checks has been exaggerated somewhat by the fact that there has been cross washing on this field, the soil working in a more or less diagonal direction from the unlimed portion of Plot 12 to the limed half of Plot 1.

Effect of Lime and of Fertilizer Applications.

Even though the uniformity of conditions is not as great as could be desired, the results from the use of many of the plant food and lime combinations are so striking as to be beyond the range of probable experimental error. Table 8 has accordingly been prepared, showing the comparisons for a number of the more important crops grown. From this table the following facts are developed: —

1. The effect of lime is very marked, but crop increase from its use is less when it is added to phosphoric acid alone, or to phosphoric acid and nitrogen, than when added to any other treatment. In general, the phosphoric acid and nitrogen treatment on the unlimed portion of the field leads all except the complete fertilizer. On the limed portion, however, complete fertilizer, phosphoric acid and potash, nitrogen and potash, and, occasionally, potash alone are superior.

2. The gain from applying lime in addition to a ration of potash alone is very much greater than from applying it in addition to phosphoric acid.

3. Potash has not given as marked results as on the South Soil Test.

4. The use of potash, phosphoric acid and lime has maintained yields at a comparatively high level, despite the infrequency with which clovers have been grown.

5. Nitrogen, used in addition to phosphoric acid and potash, has given fairly large increases in crop.

Effect of Lime on the Availability of Soil Potash.

On the limed half of this field there are three comparisons — namely, nitrogen with and without potash, phosphoric acid with and without potash, nitrogen and phosphoric acid with and without potash — where the effect of lime in increasing the availability of soil potash should be apparent. Table 9 shows the crop yields secured and presents the estimated gain from the use of potash in each case.

TABLE 8. — *The Interrelation of Lime and Fertilizer (Yields per Acre).*

Crop.	Average of Checks (Plots 1, 4, 8, 12).			Nitrogen (Plot 2).			Phosphoric Acid (Plot 3).			Potash (Plot 5).		
	Limed.	Unlimed.	Apparent Gain from Liming.	Limed.	Unlimed.	Apparent Gain from Liming.	Limed.	Unlimed.	Apparent Gain from Liming.	Limed.	Unlimed.	Apparent Gain from Liming.
Grass and clover:												
1903	968	445	-	3,140	1,520	-	1,560	950	-	950	660	-
1904	1,133	760	-	1,690	2,020	-	800	1,060	-	2,700	670	-
1908	1,895	760	-	3,880	3,280	-	1,600	940	-	2,380	860	-
1909	1,543	1,083	-	1,780	1,980	-	1,420	1,260	-	3,640	1,050	-
1914	2,463	1,065	-	2,870	2,020	-	1,680	1,490	-	5,540	1,280	-
1915	2,240	735	-	1,580	1,440	-	1,380	1,180	-	6,750	1,580	-
Average	1,707	808	+899	2,490	2,043	+447	1,407	1,147	+260	3,660	1,017	+2,643
Beans (green weight), 1918	1,005	1,680	—675	960	1,240	—280	800	960	—160	3,840	2,320	+1,520
Cabbage, 1917	18,410	1,365	+17,045	23,240	3,080	+20,160	9,220	9,800	—580	22,680	1,580	+21,100
Corn, grain (bushels):												
1905	13.7	8.7	-	9.1	13.9	-	5.9	7.8	-	18.4	5.7	-
1916	27.1	20.2	-	19.7	34.5	-	21.7	35.1	-	36.9	25.9	-
Average	20.4	14.5	+5.9	14.4	24.2	—9.8	13.8	21.4	—7.6	27.8	15.8	+12.0
Corn, stover:												
1905	2,810	2,800	-	3,960	480	-	2,640	3,400	-	4,400	4,040	-
1916	1,800	1,700	-	1,600	2,200	-	1,600	3,000	-	2,600	3,000	-
Average	2,305	2,250	+55	2,780	1,340	+1,440	2,120	3,200	—1,080	3,500	3,520	—20
Soy beans (bushels):												
1906	7.6	10.5	-	3.5	4.5	-	4.0	5.5	-	12.4	8.3	-
1910	17.7	12.1	-	19.3	14.8	-	13.8	11.4	-	24.8	9.0	-
1911	6.3	10.6	-	2.1	4.7	-	.9	4.7	-	20.3	14.5	-
Average	10.5	11.1	—.6	8.3	8.0	+.3	6.2	7.2	—1.0	19.2	10.6	+8.6

Soy beans, straw:												
1906	503	660	-	490	440	-	400	380	-	720	520	-
1910	3,235	1,625	-	3,480	3,140	-	2,800	2,680	-	1,560	1,680	-
1911	2,033	1,848	-	1,480	1,450	-	950	1,530	-	2,820	2,160	-
Average	1,924	1,378	+546	1,817	1,677	+140	1,383	1,530	—147	1,700	1,453	+247
Onions (bushels):												
1899	19.5[1]	3.7[1]	-	91.4	18.7	-	12.3	6.5	-	161.7[1]	3.1	-
1900	95.9	35.2	-	155.0	50.0	-	37.7	17.3	-	383.5	37.7	-
Average	57.7	19.5	+38.2	123.2	34.4	+88.8	25.0	11.9	+13.1	272.6	20.4	+252.2
Potatoes (bushels), 1902	48.7	54.1	—5.4	47.6	50.7	—3.1	48.0	59.3	—11.3	81.7	73.3	+8.4
Rye, grain (bushels):												
1913	33.9	24.1	-	36.4	30.7	-	28.9	29.6	-	35.3	28.9	-
1921	13.1	8.6	-	11.8	10.0	-	12.1	11.8	-	15.5	10.4	-
Average	23.5	16.4	+7.1	24.1	20.4	+3.7	20.5	20.7	—.2	25.4	19.7	+5.7
Rye, straw:												
1913	5,075	3,725	-	6,220	4,060	-	5,180	3,860	-	5,220	4,380	-
1921	1,515	1,010	-	1,340	1,240	-	1,340	1,490	-	1,820	1,320	-
Average	3,295	2,368	+927	3,780	2,650	+1,130	3,260	2,675	+585	3,520	2,850	+670

[1] Uncertainty as to accuracy, as the labels were accidentally moved.

TABLE 8. — *The Interrelation of Lime and Fertilizer (Yields per Acre)* — Concluded.

Crop.	Phosphoric Acid and Nitrogen (Plot 6).			Potash and Nitrogen (Plot 7).			Phosphoric Acid and Potash (Plot 9).			Complete Fertilizer (Plot 10).		
	Limed.	Unlimed.	Apparent Gain from Liming.	Limed.	Unlimed.	Apparent Gain from Liming.	Limed.	Unlimed.	Apparent Gain from Liming.	Limed.	Unlimed.	Apparent Gain from Liming.
Grass and clover:												
1903	3,180	1,830	-	2,190	1,820	-	920	620	-	2,830	2,330	-
1904	3,130	2,330	-	2,380	1,970	-	6,160	940	-	7,240	2,820	-
1908	4,600	3,720	-	3,800	3,240	-	3,240	800	-	4,730	4,240	-
1909	2,760	2,010	-	2,980	1,240	-	3,840	920	-	2,520	1,790	-
1914	3,840	2,540	-	4,080	2,000	-	4,420	1,030	-	6,110	2,600	-
1915	4,190	1,280	-	5,560	960	-	5,220	580	-	5,800	900	-
Average	3,617	2,285	+1,332	3,498	1,872	+1,626	3,967	815	+3,152	4,872	2,447	+2,425
Beans (green weight), 1918	2,200	1,980	+220	4,360	2,380	+1,980	3,040	1,680	+1,360	3,740	2,500	+1,240
Cabbage, 1917	27,440	23,160	+4,280	28,000	1,000	+27,000	32,720	13,880	+18,840	45,400	33,360	+12,040
Corn, grain (bushels):												
1905	29.2	20.2	-	29.5	12.5	-	34.2	11.3	-	43.1	36.2	-
1916	41.3	43.3	-	45.7	25.1	-	48.1	30.3	-	51.2	38.3	-
Average	35.3	31.8	+3.5	37.6	18.8	+18.8	41.2	20.8	+20.4	47.2	37.8	+9.4
Grain, stover:												
1905	3,680	3,600	-	3,720	2,960	-	3,400	4,520	-	4,840	5,840	-
1916	2,800	3,600	-	3,800	2,900	-	4,000	2,500	-	4,200	4,200	-
Average	3,240	3,600	—360	3,760	2,930	+830	3,700	3,510	+190	4,520	5,020	—500
Soy beans (bushels):												
1906	9.5	6.9	-	14.1	9.7	-	10.3	6.9	-	14.1	7.9	-
1910	18.6	14.5	-	19.0	8.3	-	19.7	4.8	-	16.6	8.3	-
1911	6.9	10.9	-	20.7	14.5	-	15.9	14.3	-	20.2	17.1	-
Average	11.7	10.8	+.9	17.9	10.8	+7.1	15.3	8.7	+6.6	17.0	11.1	+5.9

Soy beans, straw:												
1906	760	520	-	780	740	-	600	420	-	920	400	-
1910	4,120	2,160	-	1,820	1,520	-	1,460	1,040	-	3,240	2,200	-
1911	2,600	2,290	-	3,000	2,360	-	2,880	3,370	-	3,830	3,610	-
Average	2,493	1,657	+836	1,867	1,540	+327	1,647	1,610	+37	2,663	2,070	+593
Onions (bushels):												
1899	145.4	143.1	-	200.0[1]	3.1	-	183.8	40.4[1]	-	224.6	46.2[1]	-
1900	202.3	225.8	-	310.8	9.2	-	380.0	159.6	-	488.5	136.9	-
Average	173.9	184.5	–10.6	255.4	6.2	+249.2	281.9	100.0	+181.9	356.5	91.5	+265.0
Potatoes (bushels), 1902	100.3	98.0	+2.3	75.6	77.3	–1.7	113.7	91.7	+22.0	132.6	127.3	+5.3
Rye, grain (bushels):												
1913	35.3	27.9	-	35.3	22.9	-	31.1	17.1	-	35.7	21.8	-
1921	15.7	16.4	-	13.9	10.0	-	6.1	9.6	-	7.1	7.5	-
Average	25.5	22.2	+3.3	24.6	16.5	+8.1	18.6	13.4	+5.2	21.4	14.7	+6.7
Rye, straw:												
1913	5,020	4,240	-	5,620	4,720	-	5,260	3,640	-	5,600	3,780	-
1921	1,760	960	-	1,440	1,240	-	2,360	1,300	-	1,280	800	-
Average	3,390	2,600	+790	3,530	2,980	+550	3,810	2,470	+1,340	3,440	2,290	+1,150

[1] Uncertainty as to accuracy, as the labels were accidentally moved.

TABLE 9. — *Yields per Acre, Limed Portion of Field.*

Treatment.	Corn (2 Crops) (Bushels).		Grass and Clover (6 Crops) (Pounds).		Soy Beans (3 Crops) (Bushels).	
	Yield.	Gain from Use of Potash.[1]	Yield.	Gain from Use of Potash.[1]	Yield.	Gain from Use of Potash.[1]
Nitrogen alone	14.4		2,490		8.3	
Nitrogen and potash	37.6	23.2	3,498	1,008	17.9	9.6
Phosphoric acid alone	21.7		1,407		6.2	
Phosphoric acid and potash	41.2	19.5	3,967	2,560	15.3	9.1
Nitrogen and phosphoric acid	35.3		3,617		11.7	
Complete fertilizer	47.2	11.9	4,872	1,255	17.0	5.3

[1] By difference.

The large and consistent differences secured through the use of potash indicate that whatever effect the lime may have had on the availability of soil potash was relatively insignificant. This checks the results secured on the South Soil Test, as already discussed.

Miscellaneous Effects of Fertilizers on Crops.

Even though the fertilizer applications were in some cases doubled, as indicated on page 142, either the soil conditions were unfavorable or the amount of plant food applied was too small to give satisfactory crops of onions or potatoes. The yield of 488 bushels of onions on the limed complete fertilizer plot in 1900 is indeed well above the average, but still is not a large yield. In 1898 and likewise in 1901, the crop was a failure. The yield records do, however, indicate two things very strongly: first, the great importance to the onion crop of maintaining a suitable reaction of the soil; and second, the need by the crop of large quantities of all three of the essential plant foods. The potato crops of 1897 and 1902 were virtual failures.

The cabbage crop of 1917 was remarkably satisfactory and furnishes several illustrations of the fact that crops of the same size may be secured through radically different plant food treatments. As an illustration, the crop on the limed half of Plot 9, which in 1917 had been receiving phosphoric acid and potash annually for twenty-seven years, was the same as the crop on complete fertilizer without lime. Neither one of these, however, approached the crop produced with complete fertilizer and lime. Again, the crop on the limed portion of Plot 6, which had received no potash for twenty-seven years, was almost identical with that on the limed portion of Plot 7, which had received no phosphoric acid for the

PLATE I.

CROP RESPONSE TO NITROGEN AND LIME.

CABBAGES, CROP OF 1917.

Potash and phosphoric acid with lime. Yield per acre: good, 25,000 pounds; poor, 7,720 pounds.

Potash, phosphoric acid and nitrogen without lime. Yield per acre: good, 26,040 pounds; poor, 7,320 pounds.

A. Lime versus *Nitrogen.*

A very fair crop was produced with potash and phosphoric acid plus lime, or with complete fertilizer without lime.

Potash and phosphoric acid without lime. Yield per acre: good, 6,320 pounds; poor, 7,560 pounds.

Potash, phosphoric acid and nitrogen with lime. Yield per acre: good, 42,480 pounds; poor, 2,920 pounds.

B. Nitrogen with and without Lime.

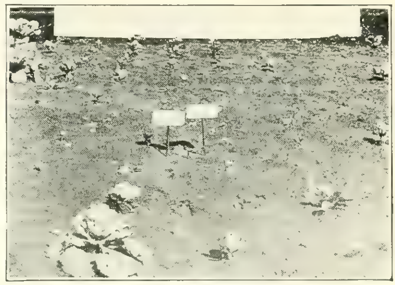
The lower left compared with upper right indicates the effect of nitrogen without lime: upper left compared with lower right the effect of nitrogen with lime.

PLATE II.

EFFECT OF ACIDULATED PHOSPHATE IN NEUTRALIZING THE EFFECT OF "SOIL ACIDITY."

CABBAGES, CROP OF 1917.

Nitrogen and phosphoric acid without lime. Yield per acre: good, 13,560 pounds; poor, 9,600 pounds.



Nitrogen and potash without lime. Yield per acre: good, 160 pounds; poor, 840 pounds. (An absolute crop failure.)

A. Without Lime.

The omission of phosphoric acid under acid soil conditions was fatal.

Nitrogen and phosphoric acid with lime. Yield per acre: good, 21,560 pounds; poor, 5,880 pounds.

Nitrogen and potash with lime. Yield per acre: good, 20,000 pounds; poor, 7,600 pounds.

B. With Lime.

A fair crop was produced without phosphoric acid, although, as shown on the opposite page, complete treatment gave much the larger crop.

same length of time. In both cases the crop was fairly satisfactory. On the other hand, nitrogen and phosphoric acid without lime gave an immensely larger crop than did nitrogen and potash without lime, — once again indicating that under certain conditions phosphorus functions in reducing need for lime, or in neutralizing the effects of soil acidity. It is also of interest to note that the yield of cabbages classified as "poor" is less absolutely, and very much less relatively, on the high-yielding plots than on the low-yielding plots.

General Summary.

The more important conclusions which may be drawn from this work, in their application to the fertility practice of Massachusetts farmers, are as follows: —

1. The kind of crop being grown and the cropping system followed determine the fertilizer needs of crops fully as much as does the soil type.
2. Where the soil is farmed without live stock, and no manure returned to the land, a complete fertilizer is more certain to bring satisfactory results than is any other fertilizer treatment.
3. The nitrogen response of crops is affected by nearness in the rotation to a legume crop, and likewise by the kind of crop. The tests indicate that where corn is grown either the first or second year following a legume, the use of fertilizer nitrogen does not bring anything more than a moderate return. The character of the season does not seem to have a dominant influence on the functioning of this plant food when applied in artificial form.
4. Where the whole crop is removed and manure not returned to the soil, large returns from the use of potash may be expected. As a corollary, the greater the extent to which crops are removed, the greater relatively will be the need for fertilizer potash; and on the other hand, the greater the extent to which crops produced are fed on the farm and manure returned, the lower will be the need for this plant food. The lesson therefore applies most particularly to farms where the supply of manure is deficient, and particularly to those where hay is cut for market, or where tobacco, onions or other money crops are raised continuously on the same land.
5. The use of lime in the cropping system followed has increased very significantly the size of crops. Apparently, however, it has had no effect on the availability of soil potash.
6. The tests show the great dependence of clover on a generous supply of lime, potash and phosphoric acid. They demonstrate a principle which is believed to be of almost universal application.
7. Soluble phosphates function in reducing, although not in eliminating, the crop damage caused by "acidity" or lack of lime.
8. Crops vary enormously in their response to the different plant foods. Except for corn and for grass and clover, however, the number of tests on individual crops is too small to permit of safe generalization.

APPENDIX.

Table I. — *South Soil Test (Yields per Acre).*

Year.	Crop.		Plot 1, Nitrate of Soda.	Plot 2, Dissolved Boneblack.	Plot 3, Check.	Plot 4, Muriate of Potash.	Plot 5, Lime.	Plot 6, Check.	Plot 7, Manure.	Plot 8, Nitrate and Boneblack.	Plot 9, Check.	Plot 10, Nitrate and Muriate.	Plot 11, Boneblack and Muriate.	Plot 12, Check.	Plot 13, Plaster.	Plot 14, Nitrate, Boneblack and Muriate.
1889	Corn	Grain (bushels)	31.25	30.00	24.75	49.25	30.75	23.50	57.50	37.00	36.75	53.00	58.00	32.50	31.25	61.50
		Stover (pounds)	1,660	1,940	1,440	2,980	1,740	1,400	4,200	2,100	2,080	3,020	3,960	2,100	1,880	4,180
1890	Corn	Grain (bushels)	45.60	49.50	43.75	62.60	51.80	45.56	59.75	50.37	42.50	53.94	65.90	52.20	52.00	71.00
		Stover (pounds)	3,750	3,590	4,850	4,590	3,660	3,500	5,520	3,260	3,130	4,235	4,880	3,525	3,540	5,320
1891	Oats	Grain (bushels)	33.13	18.13	18.13	24.07	24.69	20.31	38.44	29.07	16.56	29.69	25.94	17.50	15.94	33.13
		Straw (pounds)	2,500	1,490	1,490	1,750	1,300	1,400	4,620	2,210	1,260	2,270	1,630	1,350	1,240	3,010
1892	Grass and clover	Hay (pounds)	1,920	960	1,160	1,160	1,020	780	2,960	2,060	2,460	2,060	2,560	1,200	960	2,860
		Rowen (pounds)	720	800	640	1,400	720	600	2,240	640	660	1,040	1,900	840	680	1,340
1893	Grass and clover	Hay (pounds)	2,260	1,070	1,000	1,380	1,020	920	3,640	2,080	720	2,440	1,440	780	520	2,600
		Rowen pounds)	520	360	330	950	400	380	2,240	520	460	840	1,680	480	480	1,340
1894	Corn	Grain (bushels)	22.5	18.3	21.5	41.7	18.4	13.0	54.7	20.9	29.2	44.6	49.5	16.7	23.7	51.0
		Stover (pounds)	2,860	2,300	2,280	3,600	2,500	1,780	3,760	1,840	2,460	4,100	3,820	1,620	2,740	3,780
1895	Rye	Grain (bushels)	15.36	11.79	11.43	16.06	13.21	13.21	34.28	12.68	12.50	11.78	15.00	11.07	13.21	26.45
		Straw (pounds)	2,000	1,900	1,700	2,160	1,900	1,880	5,080	2,040	1,740	1,920	2,420	1,480	1,820	3,960
1896	Soy beans	Beans (bushels)	2.4	4.8	5.5	13.1	2.4	4.1	30.4	5.2	7.6	14.1	15.5	6.9	5.5	22.1
		Straw (pounds)	680	800	890	1,000	540	720	4,600	790	780	940	1,040	640	900	1,480
1897	Mustard (pounds)		–	–	–	–	20	–	8,500	900	–	–	500	–	–	5,100
1898	Corn	Grain (bushels)	20.6	18.5	9.8	19.8	10.4	16.9	67.7	32.0	12.5	10.9	41.2	10.5	21.9	55.9
		Stover (pounds)	2,210	1,400	1,050	1,540	1,000	1,100	3,800	1,700	800	1,300	2,440	650	1,300	2,600
1899	Corn	Grain (bushels)	13.7	3.5	3.9	49.7	7.2	5.0	75.9	21.4	5.9	47.9	59.9	3.6	6.6	72.9
		Stover (pounds)	1,160	620	730	2,760	1,100	820	5,350	1,220	840	2,360	3,160	680	990	4,450

1900	Grass and clover	Hay (pounds)	2,460	1,000	800	1,140	880	720	4,160	2,540	1,100	3,000	1,600	1,100	900	2,300
1901	Grass and clover	Hay (pounds)	900	300	400	600	500	300	3,600	1,200	400	2,100	1,900	400	200	3,300
		Rowen (pounds)	550	370	240	700	360	270	2,700	530	360	900	1,500	380	200	1,100
1902	Corn	Grain (bushels)	7.3	11.4	10.4	47.7	4.9	10.4	68.7	11.2	9.2	53.4	55.9	8.8	14.6	56.2
		Stover (pounds)	1,180	1,780	1,480	4,760	860	800	6,220	1,380	1,360	3,540	4,640	1,300	1,880	4,540
1903	Corn	Grain (bushels)	.56	.94	.94	16.61	.15	1.06	37.39	3.89	1.28	18.00	20.39	1.78	2.06	25.56
		Stover (pounds)	360	360	300	1,880	160	1,200	3,600	800	340	2,200	2,320	400	400	3,040
1904	Corn	Grain (bushels)	7.11	3.89	4.33	46.89	2.67	3.44	50.00	15.11	8.78	47.67	53.11	6.33	7.44	47.78
		Stover (pounds)	1,200	960	870	3,760	820	740	4,000	1,500	1,180	3,560	3,940	1,000	1,100	3,700
1905	Grass and clover	Hay (pounds)	2,600	400	600	2,100	1,000	700	3,200	2,000	1,200	1,500	2,300	1,400	700	1,700
1906	Grass and clover	Hay (pounds)	1,400	760	910	690	890	660	2,940	2,200	820	2,400	1,790	950	640	3,000
		Rowen (pounds)	520	295	300	440	260	325	2,670	520	390	470	1,220	410	320	1,100
1907	Corn	Grain (bushels)	1.00	.81	2.00	23.31	1.25	2.25	72.50	10.06	3.81	31.13	30.13	3.38	7.75	38.31
		Stover (pounds)	720	700	1,000	6,000	900	1,100	6,900	2,500	1,100	5,400	6,500	800	1,200	5,500
1908	Oats and crimson clover	Oat hay (pounds)	2,430	1,600	850	3,300	610	720	7,600	3,510	780	4,420	4,680	675	1,090	6,600
1909	Buckwheat (weight as cut, pounds)		5,808	2,299	3,388	6,897	3,872	4,054	16,214	7,744	4,235	10,043	9,922	3,993	4,840	14,036
1910	Corn	Grain (bushels)	14.28	5.57	3.86	24.65	5.07	9.21	57.43	8.93	4.57	26.72	37.14	17.21	13.86	41.57
		Stover (pounds)	1,700	1,800	400	2,120	500	1,100	3,700	1,900	700	2,200	2,300	1,700	800	3,080
1911	No crop		–	–	–	–	–	–	–	–	–	–	–	–	–	–
1912	Crimson clover[1]		–	–	–	–	–	–	–	–	–	–	–	–	–	–
1913	Corn	Grain (bushels)	22.6	11.0	11.7	52.6	8.7	8.4	66.8	–	–	51.2	49.7	29.1	11.0	44.4
		Stover (pounds)	2,420	2,180	2,240	4,360	2,460	1,700	5,140	–	–	3,500	4,040	2,740	1,880	3,840
1914	Soy beans (total weight, pounds)		3,500	900	1,000	6,000	1,200	1,800	11,500	–	–	9,100	7,700	1,700	1,700	9,800
1915	Corn	Grain (bushels)	22.86	10.00	8.50	40.86	5.29	10.93	60.79	–	–	34.25	37.58	16.5	10.92	35.15
		Stover (pounds)	1,490	760	615	1,980	635	720	3,520	–	–	3,365	3,250	960	805	3,400
1916	Sweet clover[1]		–	–	–	–	–	–	–	–	–	–	–	–	–	–
1917	Corn	Grain (bushels)	34.2	18.1	12.7	40.9	13.8	13.9	40.8	–	–	46.1	46.3	15.7	21.7	36.0
		Stover (pounds)	1,900	1,600	2,400	3,300	1,700	1,500	5,200	–	–	3,500	3,300	2,100	1,400	5,400
1918	Alfalfa	First cutting (pounds)	1,020	180	140	1,710	120	0	4,050	–	–	1,600	1,920	640	150	1,960
		Second cutting (pounds)	1,480	1,590	1,005	1,815	1,170	735	3,035	–	–	2,160	2,415	1,180	1,090	1,555

[1] No weights taken.

South Soil Test.

1889. An 8-rowed flint corn. 80 pounds per bushel.
1890. An early dent corn. 80 pounds per bushel.
1891. Variety, Early Race Horse. There was sown with the oats the following mixture of grass and clover: timothy, 12 pounds; redtop, 8 pounds; red clover, 6 pounds; white clover, 2 pounds; alsike clover, 3 pounds.
1894. Pride of the North. 80 pounds per bushel.
1895. After rye, the land was plowed and sown to white mustard, without additional fertilizer (July 31). Germination was quick and even, but except on the plots where manure or phosphate, lime and plaster have been applied, there was almost absolutely no growth.
1896. Medium Green. A wet fall. Beans not ripened well. Plots 1, 2, 5, 6 and 8 molded a little in stack.
1897. Unfavorable weather conditions destroyed the onions and cabbages. Sowed mustard August 14. Only four plots furnished sufficient growth to cut and weigh. Double application of manure and fertilizer made.
1898. Pride of the North. 80 pounds per bushel. On July 29 mustard was sown, covering plots and division strips. The mustard came up on all plots, but made no growth except on Plots 7 and 14, and even here was very spindling and light.
1899. Pride of the North. 80 pounds per bushel. Ears and leaves eaten by cows for 1 rod on the north end of Plot 7. Weights of stover on the best plots low because the corn, making a normal growth, was ripe long before it was cut and the stover became dry. Except on Plots 4, 7, 10, 11 and 14, the ears were very poor, immature and small.
1900. Spring sowing: awnless brome, 20 pounds; tall oat, 5 pounds; Italian rye, 8 pounds; meadow fescue, 8 pounds; orchard, 8 pounds; yellow oat, 5 pounds; medium red clover, 16 pounds.
1901. Hay; no clover except where potash has been applied. Brome grass most abundant on lime plots.
1902. From 1902 on the application of lime and plaster is at the rate of 40 pounds per plot instead of 20 pounds as heretofore.
1902. Pride of the North. 90 pounds per bushel. Corn weighed two weeks after husking. Stover varies greatly as to moisture.
1903. Pride of the North. 90 pounds per bushel. Stover well dried out.
1904. Pride of the North. 90 pounds per bushel.
1905. Spring sowing: timothy, 18 pounds; redtop, 8 pounds; meadow oat, 6 pounds; Italian rye, 8 pounds; awnless brome, 6 pounds; orchard, 15 pounds; mammoth red clover, 5 pounds; alsike, 4 pounds.
1907. Rustler white dent. 80 pounds per bushel. Weighed after drying out in glasshouse.
1908. Lincoln oats. A part of the oats on Plot 8, measuring 602 square feet, has been destroyed by Mr. Fitts' hens. Correction for same is made in the record of the yield.

Crimson clover, poor, plowed under.

1909. Product of a strip 10 feet wide across plots. The rest plowed under. Weighed as cut. Winter vetch and rye sown on September 30.
1910. 70 pounds per bushel. Fertilizer for Plot 11 probably applied to Plot 12 by mistake. Sowed alsike clover in corn, August 2.
1911. No crop. Flint Laboratory takes Plots 8 and 9. Fertilizer applied as usual, field plowed and kept cultivated and free from weeds.
1912. Crimson clover, poor, no crop.
1913. Rustler white dent. 70 pounds per bushel. Weighed after being dried in glasshouse.
1914. Medium Green. Did not mature.
1915. Longfellow. 70 pounds per bushel.
1916. Sweet clover. Mostly weeds; cut and removed without weighing.
1917. Sweet clover plowed under.

Corn, Early Canada Flint. Plot 12 received about one-half the fertilizer for Plot 11. This amount was made up on Plot 11. 70 pounds per bushel.

1918. Alfalfa, sown Aug. 20, 1917, in corn. Second cutting, Plots 2, 3, 5, 12 and 13 mostly grass and weeds; Plot 6 all grass and weeds.

TABLE II. — *Precipitation in Inches.*

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889 . .	3.29	1.45	1.46	2.42	4.71	5.01	10.52	2.72	3.17	4.58	6.04	3.57	48.94
1890 . .	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891 . .	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892 . .	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893 . .	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894 . .	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895 . .	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896 . .	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897 . .	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898 . .	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
1899 . .	2.80	3.56	7.13	1.79	1.28	4.13	4.89	2.00	7.90	1.84	2.17	2.00	41.49
1900 . .	4.08	8.12	5.76	1.85	3.78	3.65	4.67	4.11	3.67	3.72	5.87	2.40	51.68
1901 . .	1.81	0.62	5.66	5.95	6.91	0.87	3.86	6.14	4.17	3.88	2.08	7.77	49.72
1902 . .	1.72	3.54	5.29	3.31	2.32	4.54	4.66	4.65	5.83	5.59	1.27	4.27	46.99
1903 . .	3.28	4.27	6.40	2.30	0.48	7.79	4.64	4.92	1.66	2.72	2.04	3.95	44.45
1904 . .	4.74	2.45	4.48	5.73	4.55	5.35	2.62	4.09	5.45	1.74	1.35	2.75	45.30
1905 . .	3.90	1.70	3.66	2.56	1.28	2.86	2.63	6.47	6.26	2.27	2.06	3.15	38.80
1906 . .	2.18	2.73	4.90	3.25	4.95	2.82	3.45	6.42	2.59	5.69	1.98	4.49	45.45
1907 . .	2.73	1.92	1.82	1.98	4.02	2.36	3.87	1.44	8.74	5.00	4.50	3.89	42.27
1908 . .	2.25	3.53	2.86	1.97	4.35	0.76	3.28	4.27	1.73	1.57	1.06	3.05	30.68
1909 . .	3.56	5.16	3.01	5.53	3.36	2.24	2.24	3.79	4.99	1.23	1.06	2.95	39.12
1910 . .	6.14	5.08	1.37	3.07	2.67	2.65	1.90	4.03	2.86	0.93	3.69	1.72	36.11
1911 . .	2.36	2.18	3.80	1.87	1.37	2.02	4.21	5.92	3.41	8.81	3.84	4.42	44.21
1912 . .	2.18	3.16	5.70	3.92	4.34	0.77	2.61	3.22	2.52	2.07	4.03	4.04	38.56
1913 . .	3.98	2.94	6.38	3.30	4.94	0.90	1.59	2.26	2.56	5.16	2.11	3.38	39.50
1914 . .	3.72	3.36	5.52	6.59	3.56	2.32	3.53	5.11	0.52	2.09	2.62	2.89	41.83
1915 . .	6.52	7.02	0.12	3.99	1.20	3.00	9.13	8.28	1.37	2.89	2.20	5.86	51.58
1916 . .	2.56	5.27	3.97	3.69	3.21	5.34	6.85	2.49	5.08	1.01	3.29	2.85	45.61
1917 . .	3.64	1.98	4.08	1.83	4.13	5.27	3.36	7.06	2.42	6.60	0.63	2.56	43.56
1918 . .	4.11	2.99	2.91	2.78	2.47	4.01	1.84	2.22	7.00	1.32	2.87	2.95	37.47
1919 . .	2.02	2.80	4.22	2.37	6.20	1.09	4.17	4.81	4.25	1.81	6.20	1.48	41.42
1920 . .	2.74	4.45	3.63	4.71	3.65	6.26	2.06	3.62	6.74	1.54	5.62	6.02	51.04
1921 . .	2.00	2.38	3.57	6.47	4.56	3.87	6.00	2.35	1.84	1.08	6.20	1.90	42.22

TABLE III. — *Temperature and Frost Records.*

Year.	Mean Hourly Temperature (Degrees Fahrenheit).						Last Spring Frost.	First Fall Frost.
	April.	May.	June.	July.	August.	September		
1889	49.3	61.4	67.7	69.5	65.5	61.9	May 26	Sept. 21
1890	46.5	57.1	65.3	69.8	67.2	59.7	May 12	Sept. 25
1891	49.4	57.3	66.6	68.2	70.2	65.3	May 19	Oct. 12
1892	48.7	56.1	70.3	72.2	70.0	60.6	May 10	Sept. 30
1893	44.7	58.7	69.0	71.4	71.0	58.1	May 8	Sept. 3
1894	47.9	58.7	69.4	73.5	69.3	64.8	May 22	Aug. 22
1895	46.9	61.3	70.5	69.3	70.4	63.8	May 17	Aug. 22
1896	49.2	62.4	65.0	70.7	68.2	59.2	May 1	Sept. 24
1897	46.5	57.1	61.8	70.5	66.0	59.8	May 8	Sept. 22
1898	43.0	55.6	66.0	70.9	69.7	63.0	April 27	Sept. 21
1899	46.1	55.7	67.4	70.1	68.0	59.7	May 4	Sept. 14
1900	46.9	55.4	67.1	70.6	70.1	63.8	May 29	Sept. 15
1901	46.8	56.2	68.0	72.5	69.9	62.1	May 6	Sept. 26
1902	47.3	57.0	63.5	67.8	66.1	60.3	May 14	Sept. 6
1903	46.9	59.2	59.6	68.9	62.0	61.3	May 2	Sept. 25
1904	42.5	60.1	65.0	69.8	66.4	59.8	April 23	Sept. 22
1905	45.6	56.9	64.4	71.1	65.8	59.1	May 24	Sept. 12
1906	45.1	56.7	66.1	70.1	70.5	64.0	May 20	Sept. 25
1907	41.5	51.8	63.9	70.0	66.1	61.3	May 22	Sept. 27
1908	45.1	59.2	67.6	72.5	66.6	62.9	June 3	Sept. 16
1909	44.4	55.5	66.4	68.7	66.5	60.5	May 12	Oct. 13
1910	50.6	56.1	63.8	72.1	67.1	61.1	May 6	Sept. 23
1911	43.7	61.9	64.5	73.7	67.8	60.2	May 5	Sept. 14
1912	45.2	58.1	65.0	71.6	66.4	61.2	May 1	Aug. 31
1913	47.6	55.6	66.4	71.4	69.5	59.7	May 15	Sept. 10
1914	42.1	59.0	64.4	67.7	68.9	60.2	May 16	Sept. 28
1915	49.9	54.1	64.2	68.9	66.0	64.2	May 20	Sept. 23
1916	43.9	55.9	61.1	71.6	69.5	60.8	May 19	Sept. 17
1917	42.9	49.3	65.3	71.7	70.9	57.0	May 18	Sept. 11
1918	45.7	62.1	62.9	70.1	70.5	57.6	April 26	Sept. 11
1919	45.4	57.6	68.4	71.8	65.8	61.7	May 1	Sept. 18
1920	43.2	54.6	64.5	68.3	70.2	62.8	April 26	Oct. 7
1921	51.5	58.9	66.9	73.4	66.9	65.6	May 12	Oct. 9

TABLE IV. — *North Soil Test (Yields per Acre).*

Year.	Crop.		Plot 1, Check.	Plot 2, Nitrate of Soda.	Plot 3, Dissolved Boneblack.	Plot 4, Check.	Plot 5, Muriate.	Plot 6, Nitrate and Boneblack.	Plot 7, Nitrate and Muriate.	Plot 8, Check.	Plot 9, Boneblack and Muriate.	Plot 10, Nitrate, Boneblack and Muriate.	Plot 11, Plaster.	Plot 12, Check.
1890	Corn	Grain (bushels)	51.2	53.3	57.5	51.3	69.3	59.4	67.6	48.1	74.0	74.9	51.5	47.5
		Stover (pounds)	5,620	5,700	4,340	4,190	5,740	4,330	5,430	3,890	5,740	5,820	4,240	4,180
1891	Potatoes	Large (bushels)	25.67	26.33	35.67	17.33	63.33	32.33	61.33	16.67	49.33	58.33	15.67	11.67
		Small (bushels)	4.33	4.67	5.67	5.67	4.00	6.33	5.00	2.67	3.33	6.33	6.67	6.00
1892	Soy beans	Beans (bushels)	12.83	13.67	10.33	11.75	15.42	13.00	16.08	13.08	12.92	13.67	13.17	12.67
		Straw (pounds)	1,000	920	940	1,040	1,140	1,200	1,100	960	900	960	960	1,100
1893	Oats	Grain (bushels)	48.13	42.19	41.56	43.75	52.19	45.94	49.69	42.81	47.50	46.56	41.25	42.81
		Straw (pounds)	1,920	1,880	1,760	1,700	2,220	2,660	2,680	1,900	2,760	2,920	1,720	1,940
1894	Grass and clover	Hay (pounds)	640	1,320	680	280	240	1,500	680	200	440	1,620	360	220
1895	Grass and clover	Hay (pounds)	1,000	1,000	640	660	1,200	1,340	1,680	640	920	1,860	620	820
		Rowen (pounds)	–	–	–	–	340	–	–	–	220	200	–	–
1896	Cabbage	Hard (pounds)	1,200	3,240	2,080	2,640	10,520	12,000	5,800	3,800	21,200	26,200	3,320	2,240
		Soft (pounds)	9,680	8,680	8,600	8,000	7,480	9,080	4,200	6,880	7,400	6,680	6,600	4,200
1896	Turnips (pounds)		14,400	12,400	9,800	9,800	10,200	14,000	14,000	9,800	21,200	23,000	8,000	7,000
1897	Potatoes	Large (bushels)	15.50	8.87	22.00	30.00	42.00	88.33	29.67	20.67	54.00	55.33	35.83	38.00
		Small (bushels)	52.00	35.67	32.00	28.17	35.50	33.00	38.83	38.67	30.67	38.50	23.00	26.50
1898	Onions	Tops and bulbs (pounds)	940	830	1,640	1,310	1,540	9,640	650	920	2,100	4,360	680	1,540
		Merchantable (bushels)	.8	2.5	5.2	1.2	.8	116.8	.2	.8	1.9	16.3	.5	1.1
1899	Onions	Sound (bushels), unlimed	2.69	18.65	6.53	5.19	3.07	143.10	3.07	2.88[1]	40.38[1]	46.15[1]	4.04[1]	4.04
		Sound (bushels), limed	4.42	91.43	12.31	26.15	161.75[1]	145.40	200.00[1]	16.93[1]	183.80	224.60	6.35[1]	30.39[1]
1900	Onions	Sound (bushels), unlimed	6.15	50.00	17.31	72.69	37.69	225.77	9.23	38.46	159.62	136.92	4.62	23.46
		Sound (bushels), limed	41.54	155.00	37.69	132.31	383.46	202.31	310.77	107.69	380.00	488.46	23.08	102.31
1901	Onions	Tops and bulbs (pounds), unlimed	1,680	2,400	1,880	1,400	3,000	8,800	2,400	800	10,000	18,600	1,400	1,400
		Tops and bulbs (pounds), limed	3,200	4,200	2,600	2,200	11,200	8,000	13,800	2,480	13,200	22,600	2,960	2,720

[1] Uncertainty as to accuracy, as the labels were accidentally moved.

TABLE IV. — *North Soil Test (Yields per Acre)* — Concluded.

Year.	Crop.		Plot 1, Check.	Plot 2, Nitrate of Soda.	Plot 3, Dissolved Boneblack.	Plot 4, Check.	Plot 5, Muriate.	Plot 6, Nitrate and Boneblack.	Plot 7, Nitrate and Muriate.	Plot 8, Check.	Plot 9, Boneblack and Muriate.	Plot 10, Nitrate, Boneblack and Muriate.	Plot 11, Plaster.	Plot 12, Check.
1902	Potatoes	Large (bushels), unlimed	27.7	30.0	39.3	31.3	58.0	69.3	51.3	35.3	73.7	110.3	24.7	24.5
		Small (bushels)	24.0	20.7	20.0	22.7	15.3	28.7	26.0	29.3	18.0	17.0	16.0	21.7
		Large (bushels), limed	21.3	27.3	26.0	22.7	69.0	71.3	58.3	32.7	93.7	115.3	24.3	30.3
		Small (bushels)	27.7	20.3	22.0	21.3	12.7	29.0	17.3	21.3	20.0	17.3	13.7	17.3
1903	Grass and clover	Hay (pounds), unlimed	360	1,520	950	550	660	1,830	1,820	450	620	2,330	430	420
		Hay (pounds), limed	1,150	3,140	1,560	1,010	950	3,180	2,190	570	920	2,830	480	1,140
1904	Grass and clover	Hay (pounds), unlimed	1,060	1,960	1,000	560	600	2,120	1,920	560	860	2,200	560	640
		Rowen (pounds)	140	60	60	30	70	210	50	40	80	620	20	10
		Hay (pounds), limed	800	1,600	680	560	1,920	2,320	1,860	940	3,600	4,400	600	1,280
		Rowen (pounds)	80	90	120	130	780	810	520	500	2,560	2,840	80	240
1905	Corn	Grain (bushels), unlimed	8.71	13.88	7.76	5.41	5.65	20.24	12.47	4.47	11.29	36.24	10.59	16.00
		Stover (pounds)	3,100	480	3,400	3,160	4,040	3,600	2,960	1,800	4,520	5,840	2,240	3,140
		Grain (bushels), limed	7.88	9.06	5.88	8.94	18.35	29.18	29.53	18.12	34.24	43.06	19.53	20.00
		Stover (pounds)	2,520	3,960	2,640	2,920	4,400	3,680	3,720	3,520	3,400	4,840	2,320	2,280
1906	Soy beans	Beans (bushels), unlimed	10.86	4.48	5.52	13.1	8.28	6.90	9.66	7.76	6.90	7.93	5.34	10.34
		Straw (pounds),	690	440	380	630	520	520	740	600	420	400	400	720
		Beans (bushels), limed	5.17	3.45	3.97	6.72	12.41	9.48	14.14	8.79	10.34	14.14	6.03	9.83
		Straw (pounds)	430	490	400	500	720	760	780	520	600	920	400	560
1907	Grass and clover[1]		–	–	–	–	–	–	–	–	–	–	–	–
1908	Grass and clover	Hay (pounds), unlimed	1,340	3,280	940	780	860	3,720	3,240	480	800	4,240	320	440
		Hay (pounds), limed	2,160	3,880	1,600	1,560	2,380	4,600	3,800	1,640	3,240	4,730	1,580	2,220
1909	Grass and clover	Hay (pounds), unlimed	1,280	1,980	1,260	1,180	1,050	2,010	1,240	1,150	920	1,790	380	720
		Hay (pounds), limed	1,570	1,780	1,420	1,520	3,640	2,760	2,980	1,560	3,840	2,520	1,180	1,520
1910	Soy beans	Beans (bushels), unlimed	15.86	14.83	11.38	12.41	8.97	14.48	8.28	9.66	4.83	8.28	10.00	10.34
		Straw (pounds)	1,680	3,140	2,680	1,580	1,680	2,160	1,520	1,840	1,040	2,200	1,300	1,400
		Beans (bushels), limed	20.00	19.31	13.79	17.59	24.83	18.62	18.97	19.31	19.66	16.55	14.48	13.79
		Straw (pounds)	2,920	3,480	2,800	3,180	1,560	4,120	1,820	3,360	1,460	3,240	2,480	3,480

1911	Soy beans	Beans (bushels), unlimed	10.00	4.66	4.66	10.34	14.48	10.86	14.48	10.86	14.31	17.07	8.28	11.05
		Straw (pounds)	1,820	1,450	1,530	1,920	2,160	2,290	2,360	1,890	3,370	3,610	1,320	1,760
		Beans (bushels), limed	1.03	2.07	.86	2.59	20.34	6.90	20.69	15.52	15.86	20.17	1.38	6.21
		Straw (pounds)	940	1,480	950	1,450	2,820	2,600	3,000	3,100	2,880	3,830	1,920	2,640
1912	Soy beans[2]		–	–	–	–	–	–	–	–	–	–	–	–
1913	Rye	Grain (bushels), unlimed	33.6	30.7	29.6	30.4	28.9	27.9	22.9	16.0	17.1	21.8	15.4	16.4
		Straw (pounds)	5,040	4,060	3,860	4,080	4,380	4,240	4,720	2,900	3,640	3,780	3,140	2,880
		Grain (bushels), limed	33.9	36.4	28.9	33.2	35.3	35.3	35.3	30.7	31.1	35.7	35.7	37.9
		Straw (pounds)	5,200	6,220	5,180	3,940	5,220	5,020	5,620	5,080	5,260	5,600	6,000	6,080
1914	Grass and clover	Hay (pounds), unlimed	1,600	2,020	1,490	1,240	1,280	2,540	2,000	820	1,030	2,600	860	600
		Rowen (pounds)	–	–	–	–	–	–	–	–	–	–	–	–
		Hay (pounds), limed	1,840	2,870	1,680	1,830	4,140	3,800	3,080	2,320	3,620	5,310	2,400	2,980
		Rowen (pounds)	–	–	–	200	1,400	40	1,000	600	800	800	200	80
1915	Grass and clover	Hay (pounds), unlimed	920	1,440	1,180	1,020	1,580	1,280	960	520	580	900	460	480
		Rowen (pounds)	–	–	–	–	–	–	–	–	–	–	–	–
		Hay (pounds), limed	1,260	1,400	1,200	1,400	3,700	3,500	3,800	1,600	3,600	4,200	1,100	2,300
		Rowen (pounds)	220	180	180	820	3,050	690	1,760	720	1,620	1,600	280	640
1916	Corn	Grain (bushels), unlimed	21.3	34.5	35.1	28.8	25.9	43.3	25.1	16.3	30.3	38.3	19.9	14.5
		Stover (pounds)	1,600	2,200	3,000	2,600	3,000	3,600	2,900	1,400	2,500	4,200	2,000	1,200
		Grain (bushels), limed	18.7	19.7	21.7	31.5	36.9	41.3	45.7	31.9	48.1	51.2	27.9	26.4
		Stover (pounds)	1,200	1,600	1,600	2,000	2,600	2,800	3,800	2,400	4,000	4,200	2,000	1,600
1917	Cabbage	Good (pounds), unlimed	240	880	2,560	100	180	13,560	160	160	6,320	26,040	720	–
		Poor (pounds)	1,760	2,200	7,240	920	1,400	9,600	840	1,240	7,560	7,320	6,240	1,040
		Good (pounds), limed	10,120	13,640	2,980	7,240	15,360	21,560	20,400	9,320	25,000	42,480	3,980	7,520
		Poor (pounds)	10,160	9,600	6,240	9,240	7,320	5,880	7,600	10,560	7,720	2,920	9,320	9,480
1918	Beans	Total weight (pounds), unlimed	1,460	1,240	960	1,780	2,320	1,980	2,380	1,960	1,680	2,500	1,000	1,520
		Total weight (pounds), limed	960	960	800	1,180	3,840	2,200	4,360	1,180	3,040	3,740	200	700
1919	Hungarian[3]		–	–	–	–	–	–	–	–	–	–	–	–
1920	Rye[4]		–	–	–	–	–	–	–	–	–	–	–	–
1921	Rye	Grain (bushels), unlimed	10.4	10.0	11.8	7.5	10.4	16.4	10.0	9.3	9.6	7.5	4.6	7.3
		Straw (pounds)	1,280	1,240	1,490	960	1,320	960	1,240	940	1,300	800	520	860
		Grain (bushels), limed	15.2	11.8	12.1	14.3	15.5	15.7	13.9	12.1	6.1	7.1	11.1	10.7
		Straw (pounds)	1,680	1,340	1,340	1,480	1,820	1,760	1,440	1,600	2,360	1,280	1,480	1,300

[1] No weights.
[2] Plowed under.
[3] Not harvested.
[4] Spring seeded; not harvested.

NORTH SOIL TEST.

Plot 11.—Plaster, 160 pounds per acre until 1896. In 1896 increased to 400 pounds per acre. In 1902 increased to 800 pounds per acre.

Lime. — The west half of the field has been limed four times as follows: —

1899, 1 ton per acre air-slaked lime.
1904, about 1 ton per acre air-slaked lime.
1907, ½ ton per acre lime.
1916, about 2 tons per acre limestone.

1890. Variety an early dent. Sown in drills, thinned to 6 inches in the row. Cut, stooked and husked instead of being put into the silo as planned. 75 pounds per bushel.

1891. Variety, Beauty of Hebron, seed from Aroostook County, Me. Sprouted unevenly, leaving many vacant places about equally divided among the plots. Somewhat injured by frost.

1892. 60 pounds per bushel.

1893. Plots 3, 6 and 10 lodged badly; 1, 4, 5, 7, 8 and 12 stand fairly well; 5, 7 and 12 quite green; 6, 9, 10 well matured. Fall seeded: timothy, 20 pounds; redtop, 10 pounds; red clover, 6 pounds; alsike, 4 pounds.

1894. Seeded Nov. 29, 1893. Few flower stalks showing when cut. No clover. As weighed from the field the difference in the degree of dryness was quite noticeable.

1895. Hay, mostly redtop except little clover on Plots 10, 9, 7 and 5.

1896. Cabbage on west half and turnips on east half. Turnips rather poor stand, probably weighed tops and roots together.

1897. Fertilizer doubled. Potatoes under 2 ounces called "small."

1898. Fertilizer doubled.

1899. Fertilizer doubled. First liming of west half.

1900. Fertilizer doubled. Field has washed quite badly diagonally. Plot 1 washed some this summer while crop was in. Fall seeded to oats.

1901. Fertilizer doubled. Fall seeded to rye.

1902. Fertilizer doubled. Potatoes, variety, Delaware. Fall seeded: timothy, 18 pounds; redtop, 8 pounds; red clover, 5 pounds; alsike, 4 pounds.

1903. April 4: sow 15 pounds red clover. July 20: the only clover is on limed halves of Plots 9 and 10. Fertilizer doubled

1904. Fertilizer doubled. Second liming of west half. Limed half: hay, very little timothy except on Plot 10; very little redtop on Plots 9 and 10; mostly clover on Plots 5, 9 and 10. Unlimed half: hay, almost no timothy; 50 per cent or over redtop; very little clover on Plots 1, 2, 3, 4, 7, 8 and 12.

1905. Fertilizer back to normal. Sibley's Pride of the North. Total yield at 85 pounds per bushel.

1906. Medium Green. Rather a poor stand.

1907. Spring seeded, 4½ pounds mixed timothy, redtop and clover per plot. Crop mostly weeds; no weights. Third liming of west half.

1908. Mostly redtop. Small amount of clover on Plots 5 and 9, both limed and unlimed. Very little timothy on any plots.

1910. Medium Early Yellow.

1911. Medium Early Yellow.

1912. Medium Yellow soy beans; very poor stand. Plowed under and seeded to rye.

1913. Fall seeded: timothy, 20 pounds; redtop, 10 pounds; red clover, 5 pounds; alsike, 5 pounds.

1914. Rowen practically all clover.

1915. Hay. Unlimed: 1, 2, 3, 4, 11 and 12 mostly all grass; 10 half grass and half clover; 5 mostly all clover; 6, 7, 8 and 9 some clover. Limed: 2, 3 and 6 mostly all grass; 2 and 3 mostly all redtop; 1, 4, 8, 11 and 12 half grass and half clover; 5, 7, 9 and 10 mostly clover.

1916. Longfellow Corn. Fourth liming.

1917. Danish Ballhead.

1918. Yellow Eye Bean. Very unsatisfactory growth. Total weights taken as harvested. Fall seeded to rye.

1919. Plot 1 used for barium-phosphate test. Hungarian on rest of field, not harvested.

1920. Spring seeded to rye. Plowed and fall seeded to rye. No fertilizer applied.

1921. No fertilizer applied.

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